

FORM PTO-1390 US DEPARTMENT OF COMMERCE REV. 5-93PATENT AND TRADEMARK OFFICE		ATTORNEYS DOCKET NUMBER P01,0087
TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A FILING UNDER 35 U.S.C. 371		U.S. APPLICATION NO. (if known, see 37 CFR 1.5) 09/786210
INTERNATIONAL APPLICATION NO. PCT/EP99/06309	INTERNATIONAL FILING DATE 27 AUGUST 1999	PRIORITY DATE CLAIMED 28 AUGUST 1998
TITLE OF INVENTION METHOD AND APPARATUS FOR ADAPTING A TRANSMISSION POWER TO THE TRANSMISSION QUALITY OF A TRANSMISSION CHANNEL		
APPLICANT(S) FOR DO/EO/US JOSEF EICHINGER ET AL		
Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:		
<ol style="list-style-type: none"> 1. <input checked="" type="checkbox"/> This is a FIRST submission of items concerning a filing under 35 U.S.C. 371. 2. <input type="checkbox"/> This is a SECOND or SUBSEQUENT submission of items concerning a filing under 35 U.S.C. 371. 3. <input checked="" type="checkbox"/> This express request to begin national examination procedures (35 U.S.C. 371(f)) at any time rather than delay. 4. <input checked="" type="checkbox"/> A proper Demand for International Preliminary Examination was made by the 19th month from the earliest claimed priority date. 5. <input checked="" type="checkbox"/> A copy of International Application as filed (35 U.S.C. 371(c)(2)) - drawings attached. <ol style="list-style-type: none"> a. <input checked="" type="checkbox"/> is transmitted herewith (required only if not transmitted by the International Bureau). b. <input type="checkbox"/> has been transmitted by the International Bureau. c. <input type="checkbox"/> is not required, as the application was filed in the United States Receiving Office (RO/US) 6. <input checked="" type="checkbox"/> A translation of the International Application into English (35 U.S.C. 371(c)(2)) - drawings attached. 7. <input checked="" type="checkbox"/> Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. §371(c)(3)) <ol style="list-style-type: none"> a. <input type="checkbox"/> are transmitted herewith (required only if not transmitted by the International Bureau). b. <input type="checkbox"/> have been transmitted by the International Bureau. c. <input type="checkbox"/> have not been made; however, the time limit for making such amendments has NOT expired. d. <input checked="" type="checkbox"/> have not been made and will not be made. 8. <input type="checkbox"/> A translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371(c)(3)). 9. <input type="checkbox"/> An oath or declaration of the inventor(s) (35 U.S.C. 371(c)(4)). 10. <input checked="" type="checkbox"/> A translation of the annexes to the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371(c)(5)). 		
Items 11. to 16. below concern other document(s) or information included:		
11. <input checked="" type="checkbox"/> An Information Disclosure Statement under 37 C.F.R. 1.97 and 1.98; (PTO 1449, Prior Art, Search Report, 05 References).		
12. <input type="checkbox"/> An assignment document for recording. A separate cover sheet in compliance with 37 C.F.R. 3.28 and 3.31 is included. (SEE ATTACHED ENVELOPE)		
13. <input checked="" type="checkbox"/> Amendment "A" Prior to Action and Appendix "A". <input type="checkbox"/> A SECOND or SUBSEQUENT preliminary amendment.		
14. <input checked="" type="checkbox"/> A substitute specification and substitute specification mark-up.		
15. <input type="checkbox"/> A change of address letter attached to the Declaration.		
16. <input checked="" type="checkbox"/> Other items or information:		
a. <input checked="" type="checkbox"/> Submission of drawings and drawing changes		
b. <input checked="" type="checkbox"/> EXPRESS MAIL #EL655301046US dated February 28, 2001		

U.S. APPLICATION NO. 09/786210		INTERNATIONAL APPLICATION NO. PCT/EP99/06309		ATTORNEY'S DOCKET NUMBER P01,0087	
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17. <input checked="" type="checkbox"/> The following fees are submitted: BASIC NATIONAL FEE (37 C.F.R. 1.492(a)(1)(5): Search Report has been prepared by the EPO or JPO \$860.00 International preliminary examination fee paid to USPTO (37 C.F.R. 1.482) \$690.00 No international preliminary examination fee paid to USPTO (37 C.F.R. 1.482) but international search fee paid to USPTO (37 C.F.R. 1.445(a)(2)) \$710.00 Neither international preliminary examination fee (37 C.F.R. 1.482) nor international search fee (37 C.F.R. 1.445(a)(2)) paid to USPTO \$1000.00 International preliminary examination fee paid to USPTO (37 C.F.R. 1.482) and all claims satisfied provisions of PCT Article 33(2)-(4) \$ 100.00 <div style="text-align: right;">ENTER APPROPRIATE BASIC FEE AMOUNT =</div>				CALCULATIONS	PTO USE ONLY

Surcharge of \$130.00 for furnishing the oath or declaration later than <input type="checkbox"/> 20 <input type="checkbox"/> 30 months from the earliest claimed priority date (37 C.F.R. 1.492(e)).				\$	
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Claims	Number Filed	Number Extra	Rate		
Total Claims	18 - 20 =	0	X \$ 18.00	\$	
Independent Claims	03 - 3 =	0	X \$ 80.00	\$	
Multiple Dependent Claims			\$270.00 +	\$	
TOTAL OF ABOVE CALCULATIONS =				\$ 860.00	
Reduction by 1/2 for filing by small entity, if applicable. Verified Small Entity statement must also be filed. (Note 37 C.F.R. 1.9, 1.27, 1.28)				\$	
SUBTOTAL =				\$ 860.00	
Processing fee of \$130.00 for furnishing the English translation later than <input type="checkbox"/> 20 <input type="checkbox"/> 30 months from the earliest claimed priority date (37 CFR 1.492(f)).				\$	
TOTAL NATIONAL FEE =				\$ 860.00	
Fee for recording the enclosed assignment (37 C.F.R. 1.21(h). The assignment must be accompanied by an appropriate cover sheet (37 C.F.R. 3.28, 3.31). \$40.00 per property				+	
TOTAL FEES ENCLOSED =				\$ 860.00	
				Amount to be refunded	\$
				charged	\$

a. ☒ A check in the amount of \$860.00 to cover the above fees is enclosed.

b. ☐ Please charge my Deposit Account No. _____ in the amount of \$ _____ to cover the above fees. A duplicate copy of this sheet is enclosed.

c. ☒ The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any overpayment to Deposit Account No. 50-1519. A duplicate copy of this sheet is enclosed.

NOTE: Where an appropriate time limit under 37 C.F.R. 1.494 or 1.495 has not been met, a petition to revive (37 C.F.R. 1.137(a) or (b)) must be filed and granted to restore the application to pending status.

SEND ALL CORRESPONDENCE TO: SCHIFF HARDIN & WAITE PATENT DEPARTMENT 6600 Sears Tower 233 South Wacker Drive Chicago, Illinois 60606-6473	<div style="text-align: center;">  SIGNATURE </div> <div style="text-align: center;"> Mark Bergner NAME </div> <div style="text-align: center;"> <u>45,877</u> Registration Number </div>
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CUSTOMER NUMBER 26574

BOX PCT
IN THE UNITED STATES DESIGNATED/ELECTED OFFICE
OF THE UNITED STATES PATENT AND TRADEMARK OFFICE
UNDER THE PATENT COOPERATION TREATY--CHAPTER II

5

PRELIMINARY AMENDMENT A
PRIOR TO ACTION

APPLICANT(S): Josef Eichinger et al.
ATTORNEY DOCKET NO.: P01,0087
INTERNATIONAL APPLICATION NO: PCT/EP99/06309
INTERNATIONAL FILING DATE: 27 August 1999
INVENTION: METHOD AND APPARAUTS FOR ADAPTING A
TRANSMISSION POWER TO THE TRANSMISSION
QUALITY OF A TRANSMISSION CHANNEL

10

Assistant Commissioner for Patents,
Washington D.C. 20231

Sir:

15

Applicants herewith amend the above-referenced PCT application, and
request entry of the Amendment prior to examination on the United States
Examination Phase.

IN THE CLAIMS:

20

On substitute page 15:

replace line 1 with --WHAT IS CLAIMED IS:--;

Please replace original claims 1-17 with the following rewritten claims 1-17,
referring to the mark-ups in Appendix A.

25

1. (Amended) An apparatus for setting transmission power for the
transmission of digital information, comprising:
a transmission channel via which said digital information is transmitted;
a controller for boosting or reducing said transmission power; and

a quality meter for communicating a determined transmission quality of said transmission channel;

said controller setting said transmission power for a transmission of digital information dependent on a difference between a metered transmission quality
5 determined by said quality meter and a required transmission quality that is required for a transmission data rate employed for said transmission of said digital information with a specific, maximally allowed error rate.

2. (Amended) The apparatus according to claim 1, further comprising a
10 definition mechanism for defining a maximum transmission data rate of said transmission channel depending on said determined transmission quality.

3. (Amended) The apparatus according to claim 1, further comprising a connection with which a definition mechanism for determining a maximum
15 transmission data rate is supplied with a predetermined, maximally allowed error rate.

4. (Amended) The apparatus according to claim 2, further comprising a selector for selecting a transmission data rate dependent on a maximum
20 transmission data rate determined by said definition mechanism and dependent on a specific, requested transmission data rate.

5. (Amended) The apparatus according to claim 1, further comprising :
a transmitter for said transmission of digital information via said transmission
25 channel,

said transmitter comprising:

a digital channel encoding device for encoding said digital information;

a bit/symbol converter for presentation of said digital information in a form of symbols; and

a modulator for mapping said symbols onto signal values for transmission via said transmission channel;

said apparatus further comprising:

a receiver, comprising:

5 a demodulator for converting received signal values into detected symbols;

a symbol/bit converter for converting said detected symbols as a received symbol stream into an encoded bit stream; and

10 a decoder for presentation of said detected symbols as detected digital information.

6. (Amended) A method for setting a transmission power for a transmission of digital information via a transmission channel, comprising the steps of:

measuring an identified transmission quality;

15 determining a difference between said identified transmission quality and a required transmission quality that is required for a defined transmission data rate employed for said transmission of digital information with a specific, maximally allowed error rate; and

20 boosting or lowering said transmission power for said transmission of digital information depending on said difference.

7. (Amended) The method according to claim 6, further comprising the step of defining a maximum transmission data rate of said transmission channel dependent on said identified transmission quality and on a modulation method employed.

8. (Amended) The method according to claim 7, further comprising the step of defining said maximum transmission data rate dependent on a specific, maximally allowed error rate.

30

9. (Amended) The method according to claim 6, further comprising the step of transmitting said digital information which comprises the steps of:

presenting said digital information in a form of symbols;

mapping said symbols onto signal values;

5 transmitting said signal values via said transmission channel;

receiving said transmitted signal values;

detecting said received signal values;

mapping said detected signal values onto detected symbols; and

converting said detected symbols into a detected digital information.

10

10. (Amended) The method according to claim 6, further comprising the steps of:

defining a signal-to-noise ratio based on signal values received at a receiver side as a criterion for said transmission quality;

15 determining said transmission quality of said transmission channel; and

defining a maximum transmission data rate of said transmission channel depending on said identified transmission quality and on said modulation method employed.

20 11. (Amended) The method according to claim 10, further comprising the step of defining said maximum transmission data rate depending on said specific, maximally allowable error rate.

25 12. (Amended) The method according to claim 10, further comprising the step of selecting a transmission data rate, a mapping algorithm, and a corresponding encoding method depending on said maximum transmission data rate of the transmission channel determined by a definition mechanism and depending on a requested transmission data rate and a maximally acceptable error rate.

13. (Amended) The method according to claim 10, further comprising the steps of:

determining a transmission quality for different respective modulation methods;

5 defining a maximally possible data rate of said transmission channel for each modulation method; and

selecting a modulation method to be employed depending on said maximally possible data rate determined for each modulation method.

10 14. (Amended) The method according to claim 10, further comprising the step of:

boosting or lowering a transmission power for said transmission of digital information via said transmission channel depending on a difference between said identified transmission quality and said required transmission quality that is required
15 for a defined transmission data rate employed for the transmission of the digital information with a specific, maximally allowed error rate.

15. (Amended) The method according to claim 10, further comprising the step of transmitting said digital information which comprises the steps of:

20 presenting said digital information in the form of symbols;

mapping said symbols onto signal values;

transmitting said signal values via said transmission channel;

receiving said transmitted signal values;

detecting said received signal values;

25 mapping said detected signal values onto detected symbols; and

converting said detected symbols into a detected digital information.

16. (Amended) The method according to claim 10, further comprising the step of defining said signal-to-noise ratio as a criterion for said transmission quality.

30

17. (Amended) A method for adapting a transmission power for a transmission of digital information via a transmission channel to the transmission quality of the transmission channel, comprising the steps of:

determining an identified signal-to-noise ratio of said transmission channel;

boosting or lowering said transmission power depending on a difference between said identified signal-to-noise ratio of said transmission channel and a signal-to-noise ratio of a transmission data rate used for said transmission of the digital information.

Please add the following claim 18.

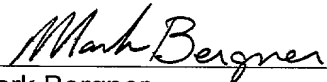
18 (New) The apparatus according to claim 3, further comprising a selector for selecting a transmission data rate dependent on a maximum transmission data rate determined by said definition mechanism and dependent on a specific, requested transmission data rate.

REMARKS

The present Amendment revises the specification and claims to conform to United States patent practice, before examination of the present PCT application in the United States National Examination Phase. Pursuant to 37 CFR 1.125 (b),
5 applicants have concurrently submitted a substitute specification, excluding the claims, and provided a marked-up copy. All of the changes are editorial and applicant believes no new matter is added thereby. The amendment, addition, and/or cancellation of claims is not intended to be a surrender of any of the subject matter of those claims.

10 Early examination on the merits is respectfully requested.

Submitted by,



(Reg. No. 45,877)

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CUSTOMER NUMBER 26574

Appendix A
Version with Markings to Show Changes Made to the Claims

This redlined draft, generated by CompareRite (TM) - The Instant Redliner, shows the differences between -
original document : Q:\DOCUMENTS\YEAR 2001\PO10087-EICHINGER-ADAPTING TRANSMISSION RATE\ORIGINAL CLAIMS.DOC
and revised document: Q:\DOCUMENTS\YEAR 2001\PO10087-EICHINGER-ADAPTING TRANSMISSION RATE\AMENDED CLAIMS.DOC

CompareRite found 156 change(s) in the text

Deletions appear as Overstrike text surrounded by []
Additions appear as Bold-Underline text

1. ~~[Apparatus]~~**(Amended) An apparatus** for setting ~~[the]~~ transmission power for the transmission of digital information~~[(13)]~~ via, **comprising:**

a transmission channel ~~[(11)]~~ with a control means (43)] **via which said digital information is transmitted;**

a controller for boosting or reducing ~~[the]~~ **said** transmission power; and
a quality meter ~~[(27)]~~ for communicating a **determined** transmission quality ~~[(28)]~~ of ~~[the]~~ **said** transmission channel~~[(11)]~~, ~~characterized in that the control means (43) sets the;~~

said controller setting said transmission power for ~~[the]~~ **a** transmission of digital information dependent on a difference between ~~[the]~~ **a metered** transmission quality ~~[(46)]~~ determined by ~~[the]~~ **said** quality meter ~~[(27)]~~ and a **required** transmission quality ~~[(47)]~~ that is required for ~~[the]~~ **a** transmission data rate ~~[(34)]~~ employed for ~~[the]~~ **said** transmission of ~~[the]~~ **said** digital information ~~[(13)]~~ with a specific, maximally allowed error rate.

2. ~~[Apparatus]~~**(Amended) The apparatus** according to claim 1,
~~[characterized by]~~ **further comprising** a definition ~~[means (29)]~~ **mechanism** for defining a maximum transmission data rate of ~~[the]~~ **said** transmission channel ~~[(11)]~~ ~~dependent]~~ **depending** on ~~[the]~~ **said** determined transmission quality~~[(28)]~~.

3. [Apparatus](**Amended**) **The apparatus** according to claim 1,
[characterized by] **further comprising** a connection with which [the] **a** definition
[means (29)] **mechanism** for determining [the] **a** maximum transmission data rate
[(28)] is supplied with a predetermined, maximally allowed error rate.

5

4. [Apparatus](**Amended**) **The apparatus** according to claim 2 [through 3,
characterized by a selection means (33)], **further comprising a selector** for
selecting a transmission data rate [(34)] dependent on [the] **a** maximum transmission
data rate [(30)] determined by [the] **said** definition [means (29)] **mechanism** and
10 dependent on a specific, requested transmission data rate[(32)].

5. [Apparatus](**Amended**) **The apparatus** according to [one of the claims 1
through 4, characterized by] **claim 1, further comprising :**

a transmitter [(10)] for [the] **said** transmission of digital information [(13)] via
15 [the] **said** transmission channel[(11)-with],

said transmitter comprising:

a digital channel encoding device [(50)] for encoding [the] **said** digital
information[.];

a bit/symbol converter [(15)] for presentation of [the] **said** digital
20 information [(13)] in [the] **a** form of symbols[(16).]; and

a modulator [(17)] for mapping [the] **said** symbols [(16)] onto signal
values [(18)] for transmission via [the] **said** transmission channel[(11).];

[and] **said apparatus further comprising:**

a receiver[(12)-with:], **comprising:**

25 a demodulator [(55)] for converting received signal values [(19)] into
detected symbols[(23).];

a symbol/bit converter [(24)] for converting [the] **said detected**
symbols as a received symbol stream [(23)] into an encoded bit stream[(53).]; and

a decoder [means (24)] for presentation of [the] **said** detected symbols
30 [(23)] as detected digital information[(25)].

6. ~~[Method]~~**(Amended) A method** for setting a transmission power for ~~[the]~~ **a** transmission of digital information ~~[(13)]~~ via a transmission channel~~[(14)]~~, ~~whereby the], comprising the steps of:~~

5 **measuring an identified** transmission quality ~~[is measured, characterized in that];~~

~~[a boosting or lowering of the transmission power for the transmission of digital information is set dependent on]~~ **determining** a difference between ~~[the]~~ **said** identified transmission quality ~~[(46)]~~ and a **required** transmission quality ~~[(47)]~~ that is
10 required for a defined transmission data rate ~~[(34)]~~ employed for ~~[the]~~ **said** transmission of ~~[the]~~ digital information ~~[(13)]~~ ~~with~~ **with a specific, maximally allowed error rate; and**

boosting or lowering said transmission power for said transmission of digital information depending on said difference.

15 7. ~~[Method]~~**(Amended) The method** according to claim 6, ~~[characterized in that]~~ **further comprising the step of defining** a maximum transmission data rate ~~[(30)]~~ of ~~[the]~~ **said** transmission channel ~~[(11)]~~ ~~is defined]~~ dependent on ~~[the]~~ **said** identified transmission quality and on ~~[the]~~ **a** modulation method ~~[(28)]~~ employed.

20 8. ~~[Method]~~**(Amended) The method** according to claim 7, ~~[characterized in that the]~~**further comprising the step of defining said** maximum transmission data rate ~~[(30)]~~ ~~is defined]~~ dependent on a specific, ~~[maximally allowed error rate (61)].~~

25 9. ~~[Method]~~**(Amended) The method** according to ~~[one of the claims 6 through 8, characterized in that the following steps are implemented for the transmission of the]~~ **claim 6, further comprising the step of transmitting said** digital information ~~[(13)]~~; **which comprises the steps of:**

~~[presentation of the]~~**presenting said** digital information ~~[(13)]~~ in ~~[the]~~ **a** form
30 of symbols~~[(16)]~~;

mapping [the] **said** symbols [(16)] onto signal values[(18)];
transmitting [the] **said** signal values [(18)] via [the] **said** transmission
channel[(11)];
receiving [the] **said** transmitted signal values[(21)];
5 detecting [the] **said** received signal values[(21)] and;
mapping [the] **said** detected signal values onto detected symbols[(23)]; and
converting [the] **said** detected symbols [(23)] into a detected digital
information[(25)].

10 10. [Method](**Amended**) **The method** according to [one of the claims 6
through 9, characterized in that] **claim 6, further comprising the steps of:**

defining a signal-to-noise ratio based on signal values received at [the] a
receiver side [is defined] as a criterion for [the] **said** transmission quality[(28)];

determining [the] **said** transmission quality [(28)] of [the] **said** transmission
15 channel[(11)]; and

defining a maximum transmission data rate [(30)] of [the] **said** transmission
channel [(11)] dependent] **depending** on [the] **said** identified transmission quality
and on [the] **said** modulation method [(28)] employed.

20 [[sic]

11. Method] **11. (Amended) The method** according to claim 10, [characterized in
that the]**further comprising the step of defining said** maximum transmission data
rate [(32)] is additionally defined dependent on a] **depending on said** specific,
25 maximally allowable error rate[(61)].

12. [Method](**Amended**) **The method** according to [one of the claims 10 and
11, characterized in that, additionally,] **claim 10, further comprising the step of**
selecting a transmission data rate[(34)], a mapping algorithm, and a corresponding
30 encoding method [is selected dependent on the] **depending on said** maximum

transmission data rate [(30)] of the transmission channel [(11)] determined by [the] a definition [means (29)] mechanism and [dependent] depending on a requested transmission data rate [(32)] and a maximally acceptable error rate[(64)].

5 13. ~~[Method]~~**(Amended) The method** according to ~~[one of the claims 10 through 12, characterized in that]~~ **claim 10, further comprising the steps of:**

~~[the]~~**determining a** transmission quality [(280 is respectively determined)] for different respective modulation methods;

defining a maximally possible data rate [(30)] of [the] said transmission
10 channel [(11) is defined] for each modulation method; **and**

selecting a [the] modulation method to be employed ~~[is selected dependent on the maximum transmission]~~ **depending on said maximally possible** data rate [(30)] determined for each modulation method.

15 14. ~~[Method]~~**(Amended) The method** according to ~~[one of the claims 10 through 13, characterized in that]~~ **claim 10, further comprising the step of:**

boosting or lowering a transmission power for [the] said transmission of digital information [(43)] via [the] said transmission channel ~~[is boosted or lowered dependent on the]~~ **depending on a** difference between [the] said identified
20 transmission quality [(46)] and ~~[a]~~ **said required** transmission quality [(47)] that is required for a defined transmission data rate [(34)] employed for the transmission of the digital information [(43)] with a specific, maximally allowed error rate.

25 15. ~~[Method]~~**(Amended) The method** according to ~~[one of the claims 10 through 14, characterized in that the following steps are implemented for the transmission of the]~~ **claim 10, further comprising the step of transmitting said** digital information [(43)]: **which comprises the steps of:**

~~[presentation of the]~~**presenting said** digital information [(43)] in the form of symbols[(46)];

30 mapping [the] said symbols [(46)] onto signal values[(48)];

transmitting [the] **said** signal values [(18)] via [the] **said** transmission channel[(11)];

receiving [the] **said** transmitted signal values[(21)];

detecting [the] **said** received signal values[(21) and];

5 mapping [the] **said** detected signal values onto detected symbols[(23)]; and
converting [the] **said** detected symbols [(23)] into a detected digital information[(25)].

16. ~~[Method]~~ **(Amended) The method** according to ~~[one of the claims 10 through 15, characterized in that the]~~ **claim 10, further comprising the step of**
10 **defining said** signal-to-noise ratio ~~[is defined]~~ as **a** criterion for [the] **said** transmission quality[(28)].

17. ~~[Method]~~ **(Amended) A method** for adapting a transmission power for
15 [the] **a** transmission of digital information [(13)] via a transmission channel [(11)] to the transmission quality of the transmission channel[(11)], comprising the ~~[following]~~ **steps of:**

determining [the] **an identified** signal-to-noise ratio [(46)] of [the] **said** transmission channel;

20 boosting or lowering [the] **said** transmission power ~~[dependent]~~ **depending** on [the] **a** difference between [the] **said** identified signal-to-noise ratio [(46)] of [the] **said** transmission channel [(11)] and [the] **a** signal-to-noise ratio [(47)] of [the] **a** transmission data rate [(34)] used for [the] **said** transmission of the digital information[(13)].

09/786210

JC02 Rec'd PCT/PTO 2 8 FEB 2001

BOX PCT
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UNDER THE PATENT COOPERATION TREATY--CHAPTER II

SUBMISSION OF DRAWING CHANGES

APPLICANT(S): Josef Eichinger et al.
ATTORNEY DOCKET NO.: P01,0087
INTERNATIONAL APPLICATION NO: PCT/EP99/06309
INTERNATIONAL FILING DATE: 27 August 1999
INVENTION: METHOD AND APPARATUS FOR ADAPTING A
TRANSMISSION POWER TO THE TRANSMISSION
QUALITY OF A TRANSMISSION CHANNEL

Assistant Commissioner for Patents,
Washington, D.C. 20231

Sir:

Enclosed is one sheet of drawings, showing in red, the changes
to Figure 3. Approval of the changes is respectfully requested.

Submitted by,

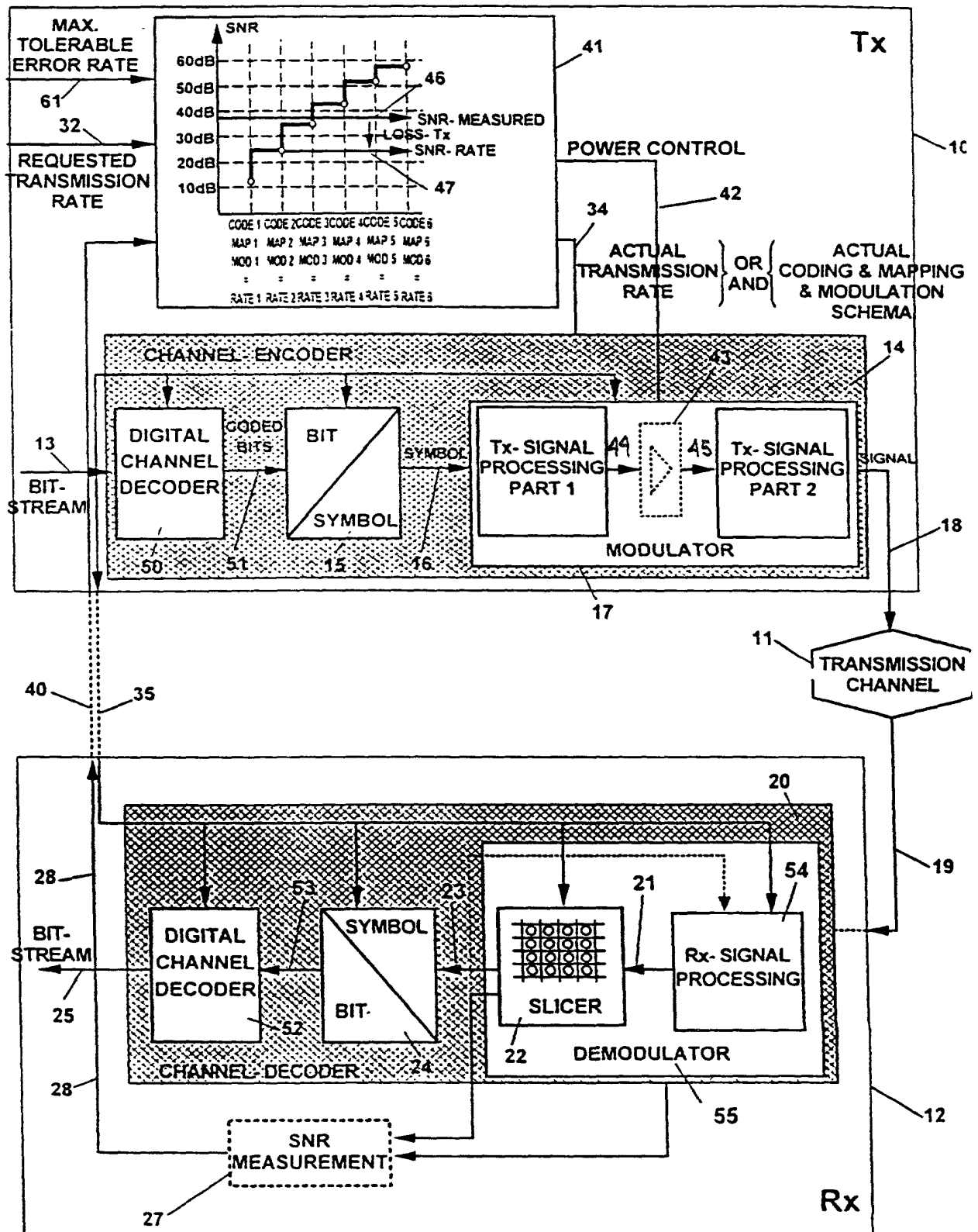


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CUSTOMER NUMBER 26574

Fig. 3



SPECIFICATION

TITLE

METHOD AND APPARATUS FOR ADAPTING A TRANSMISSION POWER TO
THE TRANSMISSION QUALITY OF A TRANSMISSION CHANNEL

5 BACKGROUND OF THE INVENTION

Field of the Invention

1 The invention is directed to a method for adapting transmission power to the transmission quality of a transmission channel.

10 Description of the Related Art

2 The need for digital transmission systems has exponentially risen in recent decades. Digital transmission systems are generally classified into the function units shown in Fig. 1. A message source 1 generates information that a transmitter transmits to a receiver via a transmission channel 4. The properties of the
15 information to be transmitted are dependent on the message source. Messages to be transmitted can, for example, be an audio signal or a video signal. Analog transmission systems transmit analog signals that were generated by analog message sources directly via the transmission channel upon employment of traditional analog modulation methods. Such modulation methods are, for example,
20 amplitude modulation, frequency modulation or phase modulation. In digital transmission systems, the information to be transmitted is converted into a sequence of binary numbers. In order to be able to utilize the capacity of the channel optimally, the message to be transmitted is represented with as few binary numbers as necessary. To this end, a source encoder is employed that converts the
25 messages to be transmitted into sequences of signal values and encodes them so that the channel can transmit them. The source encoder attempts to convert the messages to be transmitted into binary numerals as efficiently as possible.

3 The sequence of binary numbers generated by the source encoder is transmitted by the channel to the receiver. Such an actual channel can, for
30 example, be composed of a line connection, a coaxial cable, a light waveguide (LWL), a radio connection, a satellite channel or a combination of these transmission

values and ~~[encoding]~~ **encodes** them~~[,]~~ so that the channel can transmit them. The source encoder ~~[thereby]~~ attempts to convert the messages to be transmitted into binary numerals as efficiently as possible.

3 The sequence of binary numbers generated by the source encoder is transmitted by the channel to the receiver. Such an actual channel can, for example, be composed of a line connection, ~~[of]~~ a coaxial cable, ~~[of]~~ a light waveguide (LWL), ~~[of]~~ a radio connection, a satellite channel or a combination of these transmission media. Such channels cannot directly transmit the sequence of binary numbers from the transmitter. To that end, the sequence of digital information must be converted into signal values that correspond to the properties of the channel~~[. Such]~~ **by** a device ~~[is]~~ called a digital modulator. Such a modulator is part of the channel encoder 3, which additionally comprises a discrete channel encoder in order to provide the information to be transmitted with an error protection adapted to the channel.

~~[It]~~ **4 The transmission channel 4** is not assumed ~~[of the transmission channel 4 that it works]~~ **to work** error-free; rather, it is assumed that a noise source 5 will modify the transmitted signals during the transmission with a specific probability.

5 Such disturbances can, for example, be a cross-talk of signals that are transmitted on neighboring channels. The disturbances can likewise be caused by thermal noise that is generated in the electronic circuit such as~~[, for example,]~~ amplifiers and filters that are employed in the transmitter and in the receiver. Given line connections, disturbances can additionally be caused by ~~[switchings]~~ **switching** and can be additionally caused by meteorological influences given radio or satellite connections such as~~[, for example,]~~ thunderstorms, hail or snow. Such influences modify the transmitted signal and cause errors in the received digital signal sequence.

6 In order to nonetheless assure a relatively dependable transmission, the channel encoder increases the redundancy of the (binary) sequence to be transmitted. With the assistance of this redundancy added by the transmitter, the receiver is assisted in the decoding of the information-carrying signal sequence. To this end, for example, the channel encoder combines a specific plurality of signals to form blocks and a plurality of check signals (one parity bit in the simplest case) is added. In this way, k information bits are always simultaneously encoded, ~~[whereby]~~

where each k bit sequence has an unambiguous n bit sequence~~], what is referred to as the code word,]~~ **(the “code word”)** allocated to it. The redundancy added in this way can be indicated with the ratio n/k . This likewise corresponds to the channel bandwidth that must be correspondingly increased in order to transmit the information sequence expanded by the added redundancy.

7 Alternatively, an enhanced dependability against channel disturbances can also be achieved by, for example, ~~[by]~~ an increase in the transmission power. Since the increase in the transmission power, however, is relatively expensive, the dependability is usually achieved given available bandwidth by increasing the required channel bandwidth.

8 International patent document WO 97/03403 discloses ~~[the]~~ a data transmission with variable data rate in a cellular radio system. Before data are transmitted via a transmission channel, they usually pass through two encoding units, namely a voice encoding and a channel encoding. The voice encoding reduces the quantity of data required for the transmission of a specific information. The channel encoding attaches further data to the data encoded in this way in order to also assure a dependable transmission given a disturbed channel. Effective voice encoding methods supply a data stream with a variable data rate dependent on the information to be encoded. Such a saving of data can usually not be directly used for other data transmissions in mobile radiotelephony. The data saved by the effective voice encoding are therefore used in order to lower the transmission power of the transmitter.

9 In the transmission of one bit with the data rate R bit/s, the modulator always allocates a signal curve or~~], respectively,]~~ a signal value (referred to below only as ~~[signal value)]~~ **“signal value”**) $s_1(t)$ to the binary number 0 and allocates a signal value $s_2(t)$ to the binary number 1. This transmission of each individual bit by the channel encoder is called binary modulation. Alternatively, the modulator can simultaneously transmit k information bits upon employment of $M = 2^k$ different signal values $s_i(t)$ with $i = 1, 2, \dots, M$, ~~[whereby]~~ where each of the 2^k possible k-bit sequences is allocated to a signal value.

10 At the receiver side of a digital transmission system, the digital demodulator processes the signal value transmitted in the channel (potentially modified) and allocates an individual number to each signal value that represents an estimate of

the transmitted data symbol (for example, binary).

11 After reception of a signal in the receiver, the demodulator must decide which of the M possible signal values was sent. This decision is implemented in a decision unit (slicer) ~~[, whereby]~~ **in which** the decision ~~[should be]~~ **is** made with a minimal error probability. This decision unit allocates a reception value (usually edited) to one of the M possible symbol values.

12 When, for example, a binary modulation is employed, the demodulator must decide when processing each received signal whether the transmitted bit is a ~~[matter of a]~~ 0 or ~~[of]~~ a 1. In this case, the demodulator implements a binary decision.

Alternatively, the demodulator can also implement a ternary decision, whereby the demodulator decides for "0", "1" or "no decision" ~~[dependent]~~ **depending** on the quality of the received signal.

13 The decision process of a demodulator can be viewed as quantization, ~~[whereby]~~ **where** binary and ternary decisions are specific instances of a demodulation that quantizes the Q-level, ~~[whereby]~~ **where** $Q \geq 2$ applies. In general, digital communication systems employ a high-order modulation, ~~[whereby]~~ **where** $m = 0, 1 \dots M-1$ represents the possible transmitted symbols.

14 When the transmitted information contains no redundancy, the demodulator must decide at every predetermined time interval which of the M-signal values was transmitted. When the transmitted information, in contrast, contains redundancy, then the demodulator reconstructs the original information sequence on the basis of the code employed by the channel encoder and on the basis of the redundancy of the received signals. Dependent on the demands defined by the applications, the channel encoder generates signal blocks that make it possible for the channel decoder to either only identify where the specific disturbances have occurred (error-recognizing encoding) or to even be able to automatically correct (error-correcting encoding) errors caused by disturbances (up to a specific maximum number per signal block).

15 One criterion for the dependability with which the messages are transmitted from the transmitter to the receiver is represented by the error rate. The error rate indicates the average probability with which a bit error occurs at the output of the decoder. The bit error rate indicates the ~~[plurality]~~ **number** of error bits occurring at the receiver divided by the total number of received bits per time unit. The bit error

rate (or symbol error rate when the error frequency of symbols is evaluated) is the most important quality criterion of a digital transmission system. In general, the error probability is dependent on the code properties, on the nature of the signal values employed for the transmission of the information via the channel, on the transmission power, on the properties of the channel, i.e., the strength of the noise, the type of noise, etc., and on the demodulation and decoding method. The significance of the bit error rate for digital transmission systems corresponds to the signal-to-noise ration (SNR) of analog transmission systems.

16 The error rates with which symbols occur at the output of the demodulator or~~[, respectively,]~~ with which bits occur at the output of the decoder are dependent on the properties of the transmission medium, i.e., of the transmission channel, on the selected modulation and encoding strategy and on the average power of the transmission signal. For adaptation of a transmission data rate to a transmission channel, the transmission properties of the transmission channel are traditionally determined by communicating a bit or~~[, respectively,]~~ symbol sequence that is known to the receiver. The error rate of the channel can be determined on the basis of a rated-actual comparison in the receiver. In this way, the quality of the current data transmission can be identified. What is disadvantageous about this method, however, is that only the measurement of a possible combination of transmission power, encoding method and modulation method can be measured. So that a separate measurement need not be implemented for every possible data rate or~~[, respectively,]~~ transmission power, iterative methods are usually utilized for finding an optimum transmission data rate or~~[, respectively,]~~ transmission power.

17 United Kingdom patent GB-A-2303769 discloses [a] communication equipment that is in the position of setting the transmission data rate. First, a transmission data rate is selected dependent on the measured electrical field strength. This transmission data rate is subsequently additionally varied dependent on a measured bit error rate, namely, reduced given a high error rate and boosted given a low error rate. The bit error rate measurement serves as **the** basis for a fine adjustment of the transmission data rate.

SUMMARY OF THE INVENTION

18 An object of the invention is to create an improved method and an improved

apparatus for adapting the transmission power to the transmission channel.

19 This object is achieved ~~[for an apparatus with the technical teaching of patent claim 1 and is achieved for a method with the technical teaching of patent claims 6.~~

by an apparatus for setting transmission power for the transmission of digital information, comprising a transmission channel via which the digital information is transmitted; a controller for boosting or reducing the transmission power; and a quality meter for communicating a determined transmission quality of the transmission channel; the controller setting the transmission power for a transmission of digital information dependent on a difference between a metered transmission quality determined by the quality meter and a required transmission quality that is required for a transmission data rate employed for the transmission of the digital information with a specific, maximally allowed error rate.

20 This object is also achieved by a method for setting a transmission power for a transmission of digital information via a transmission channel, comprising the steps of: measuring an identified transmission quality; determining a difference between the identified transmission quality and a required transmission quality that is required for a defined transmission data rate employed for the transmission of digital information with a specific, maximally allowed error rate; and boosting or lowering the transmission power for the transmission of digital information depending on the difference.

21 Inventively, a transmission power is set dependent on the measured transmission quality of the transmission channel. With the measurement of the transmission quality, particularly with a receiver-side determination of the signal-to-noise ratio based on the received signals, the transmission power can be minimized ~~[dependent]~~ **depending** on the transmission data rate employed.

22 In this way, the transmission sequence of modulator/transmission channel/demodulator can be measured on line (i.e., during the data transmission) independently of the selected encoding method, and the transmission power can be set such dependent on the required data transmission rate that a predetermined bit or ~~[, respectively,]~~ symbol error rate is guaranteed. The measurement of the transmission quality is ~~[the]~~ **a** prerequisite in order to define the minimum transmission power ~~[such]~~ for a defined transmission rate **such** that a maximally

acceptable error rate is not exceeded.

23 The power of the transmitter can be adapted to the required transmission quality in that the transmission power is raised or~~[, respectively,]~~ lowered dependent on a difference between a measured signal-to-noise ratio and a required signal-to-noise ratio. In this way, the transmission power, based on a measurement of the signal-to-noise ratio, can be optimally adapted, i.e., minimized, to the selected transmission method and the existing transmission channel, i.e., **the** lowest possible transmission power given simultaneous assurance of the quality demands and adherence to the required transmission rate. The noise emissions are thus minimized and, at the same time, the transmission capacity of neighboring systems that work on the same frequency band is increased.

~~[Advantageous developments of the invention are recited in the subclaims.]~~

24 Advantageous developments for the apparatus include providing a definition mechanism for defining a maximum transmission data rate of said transmission channel depending on said determined transmission quality. The apparatus may further comprise a connection with which a definition mechanism for determining a maximum transmission data rate is supplied with a predetermined, maximally allowed error rate. Also, a selector for selecting a transmission data rate dependent on a maximum transmission data rate determined by said definition mechanism and dependent on a specific, requested transmission data rate can be provided. The apparatus may also include a transmitter for said transmission of digital information via said transmission channel, said transmitter comprising: a digital channel encoding device for encoding said digital information; a bit/symbol converter for presentation of said digital information in a form of symbols; and a modulator for mapping said symbols onto signal values for transmission via said transmission channel; said apparatus further comprising: a receiver, comprising: a demodulator for converting received signal values into detected symbols; a symbol/bit converter for converting said detected symbols as a received symbol stream into an encoded bit stream; and a decoder for presentation of said detected symbols as detected digital information.

25 The inventive method may further comprise the step of defining a maximum transmission data rate of said transmission channel dependent on

said identified transmission quality and on a modulation method employed. A step of defining said maximum transmission data rate dependent on a specific, maximally allowed error rate may also be provided. The method may also provide a step of transmitting said digital information which comprises the steps of: presenting said digital information in a form of symbols; mapping said symbols onto signal values; transmitting said signal values via said transmission channel; receiving said transmitted signal values; detecting said received signal values; mapping said detected signal values onto detected symbols; and converting said detected symbols into a detected digital information. Further steps may be provided, including defining a signal-to-noise ratio based on signal values received at a receiver side as a criterion for said transmission quality; determining said transmission quality of said transmission channel; and defining a maximum transmission data rate of said transmission channel depending on said identified transmission quality and on said modulation method employed. The inventive method may also include the step of selecting a transmission data rate, a mapping algorithm, and a corresponding encoding method depending on said maximum transmission data rate of the transmission channel determined by a definition mechanism and depending on a requested transmission data rate and a maximally acceptable error rate. A further embodiment of the inventive method may include the steps of: determining a transmission quality for different respective modulation methods; defining a maximally possible data rate of said transmission channel for each modulation method; and selecting a modulation method to be employed depending on said maximally possible data rate determined for each modulation method. Finally, the inventive method may involve a step of boosting or lowering a transmission power for said transmission of digital information via said transmission channel depending on a difference between said identified transmission quality and said required transmission quality that is required for a defined transmission data rate employed for the transmission of the digital information with a specific, maximally allowed error rate.

BRIEF DESCRIPTION OF THE DRAWINGS

26 Preferred exemplary embodiments of the invention are explained below on the basis of the drawing.

~~{Shown are:~~

~~Fig. 1]~~ **Fig. 1 is a block diagram illustrating** the general structure of a message transmission system;

Fig. 2 is a block schematic diagram illustrating the structure of an inventive transmission system for adapting the data rate and the modulation method to the transmission medium on the basis of receiver-side signal-to-noise ratio measurement~~[.]~~;

~~[Fig. 3]~~ **Fig. 3 is a block schematic diagram illustrating** the structure of an inventive transmission system for adapting the transmission data rate, the modulation method and the transmission power to the transmission medium on the basis of receiver-side signal-to-noise ratio measurement; and

Fig. 4 is a ~~[diagram for]~~ **graph** illustrating the “power control” for setting a transmission power dependent on a measure and on an employed transmission quality.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

27 In digital information transmission, information are transmitted between a message source (transmitter) and a receiver via a transmission medium. Such an apparatus that is located between the transmitter and the receiver is generally referred to as a channel.

28 For the transmission, the data to be transmitted are converted into code words that are matched to the transmission properties of the message channel in order to protect the data to be transmitted against among other things, transmission errors.

29 In the transmission, a character, which is generally referred to as a symbol in the signal space or channel symbol, is allocated to a bit sequence with a reversibly unambiguous, functional allocation. This symbol is subsequently mapped onto a signal curve (referred to below as ~~{signal-value}~~) **a “signal value”**). The functional allocation of a symbol to a bit sequence in the transmitter is called encoding or mapping; the mapping of such a symbol or of a plurality of such symbols onto a signal value is called modulation.

30 The reversal of this mapping sequence occurs in the receiver. Whereas the demodulation, i.e., the allocation of a reception signal to a symbol, can usually not be implemented error-free due to distortions or superimposed disturbances of the channel, the decoding, i.e., the conversion of a detected symbol into the corresponding bit sequence, does not ~~represent any problems.~~

suffer from similar difficulties.

31 Fig. 2 shows the structure of a transmission system that sets a desired data rate after determination of the quality of the transmission channel. ~~[A digital]~~ **Digital** information, particularly a bit sequence 13, is transmitted to a receiver 12 from a transmitter 10 via a transmission channel 11, ~~[said]~~ **the** receiver 12 outputting the received digital information, particularly the bit sequence 25. The channel encoder 14 of the transmitter 10 contains a digital channel encoder 50, a bit/symbol converter 15 and a modulator 17. The digital channel encoder 50 adds redundancy to the incoming bit stream 13. The encoded bit stream 51 formed in this way is converted into a symbol sequence 16 in the bit/symbol converter 15, this symbol sequence 16 being in turn reversibly unambiguously mapped by a modulator 17 onto a signal curve or ~~[, respectively,]~~ signal values 18. The signal values 18 are transmitted via the transmission channel 11 to the receiver 12.

32 The channel decoder 20 of the receiver 12, which converts the received signal values 19 into a digital information 25, contains a demodulator 55, a symbol/bit converter 24 and a digital channel decoder 52 as critical components. In the demodulator, the received signal values 19 are initially edited by an analog and optional digital signal processing unit that, for example, could contain a reception amplifier, an analog-to-digital conversion, and a distortion correction means. The signal values 21 edited in this way are subsequently supplied to a decision unit ~~[or, respectively]~~ slicer 22 that allocates a symbol 23 to every received signal value 21.

33 The symbol/bit converter 24 of the channel decoder 20 ~~[allocated]~~ **allocates** and ~~[encoded,]~~ **encodes** digital information or ~~[, respectively,]~~ an encoded bit sequence 53 to each detected symbol or ~~[, respectively,]~~ each detected symbol sequence 23 according to the selected mapping method ~~[, the]~~. **The** digital information or ~~[, respectively,]~~ the bit stream 25 ~~[being]~~ **is** derived ~~[therefrom]~~ **from the digital information/encoded bit sequence 53** with the assistance of the digital channel decoder 52 according to the selected encoding method.

34 The decision unit (slicer) 22 is a basic component part of every demodulator. Such a decision unit allocates the symbol ~~[or, respectively, the symbols](s)~~ that was most probably sent to the ~~[reception-value]~~ **receiver** - usually edited. Since the set of input values of the decision unit, due to disturbances or distortions of the transmission channel, usually does not correspond to the "valid" signal values of the transmitter, i.e., the signal values that are allocated to the symbols to be transmitted, the signal-to-noise ratio 28 adjacent to the decision input can be determined from the input signal 21 and the output signal 23 of the decision unit independently of the encoding and mapping algorithm employed. To this end, an inventive receiver comprises a device 27 for measuring the signal-to-noise ratio (SNR) of the information transmitted via the transmission channel 11.

35 In a possible embodiment of a device for measuring the signal-to-noise ratio, a signal value 60 that the input of the decision unit in the demodulator would have received if the signal curve ~~[or, respectively,]~~ signal value corresponding to the detected symbol had been transmitted ~~[unfalsified]~~ **reliably** is again allocated to every detected symbol in the demodulator at the receiver side. In this way, a hypothetical input signal **is formed** corresponding to the detected symbol values that contains no signal values with channel distortions or disturbances ~~[is formed]~~. This reference signal - as long as the decision unit does not detect any incorrect symbols - thus corresponds to the original signal at the transmitter side. By subtracting this reference signal from the edited receiver signal 21, the noise signal can be acquired.

36 The average power of this reference signal formed in this way corresponds to the average power of the received undisturbed signal part. The average power of the signal adjacent at the input of the decision unit corresponds to the aggregate power of received noise and signal part. The noise power is calculated ~~[therefrom]~~ **from this** with the assistance of the previously calculated, undisturbed signal part. The signal-to-noise ratio (SNR) as a criterion for the transmission quality of the transmission channel derives from the ratio of the average power of the undisturbed signal part to the average power of the noise part.

37 What such a method avoids is that the receiver must know a specific transmission sequence, as necessary given other, traditional methods. Moreover, the determination of the error rate ensues **in** parallel to the evaluation of the transmitted symbols, i.e., online. A periodic introduction of a test sequence into the

data stream to be transmitted is therefore no longer required for the continuous measurement of the transmission quality. ~~[In this way,]~~ **This avoids** a reduction of the net data rate of the transmission channel ~~[can be avoided.~~

].

5 **38** In order to assure a high statistical dependability, a traditional method that employs a test sequence known to the transmitter and receiver must cover a great number of errors, usually several hundred. The traditional methods require very long measuring times in order to detect a corresponding plurality of errors for the very low bit error rates of, for example, 10^9 that are generally required. The inventive method, 10 in contrast, is based on the interpretation of the measured signal-to-noise ratio during ongoing transmission. Since, however, ~~[only]~~ significantly shorter measuring times are required for the interpretation of the average powers when compared to the comparable interpretation of the symbol or~~[, respectively,]~~ bit stream, the transmission quality can be determined far faster with the inventive method.

15 ~~[Dependent]~~ **39 Depending** on the selected encoding and mapping method, there is always an unambiguous functional relationship between the signal-to-noise ratio 28 and a symbol error rate or~~[, respectively,]~~ bit error rate. The signal-to-noise ratio thus qualifies the transmission properties of the channel and of the momentarily selected modulation or~~[, respectively,]~~ demodulation method independently of the 20 selected encoding or~~[, respectively,]~~ mapping method. Via a measurement of the signal-to-noise ration 28 of a transmission channel 11, thus, the encoding or~~[, respectively,]~~ the mapping method of the current modulation/demodulation method can be defined such that a desired data throughput can be set for an error rate that can just be accepted. To this end, the identified signal-to-noise ratio 28 is supplied 25 to a ~~[device]~~ **device/definition mechanism** 29 for determining a maximum transmission data rate 30 or~~[, respectively,]~~ an encoding and mapping method.

~~[Dependent]~~ **Depending** on the signal-to-noise ratio 28, preferably determined in decibels (dB) according to a known relationship, the device 29 defines an encoding and mapping method or~~[, respectively,]~~ a maximum transmission data rate 30 for the 30 current modulation and demodulation method that enables a maximum data throughput given the existing signal-to-noise ~~[ration]~~ **ratio** 28. The maximally acceptable error rate 61 and of the modulation ~~[method]~~ **method/strategy** 62 appear as parameters of the conversion characteristic of the device 29. ~~[Dependent]~~

Depending on the measured transmission quality 28 of the transmission channel 11 and ~~[dependent]~~ **depending** on the current modulation/demodulation method 62 and ~~[dependent]~~ **depending** on a maximally allowed error rate in the transmission of the digital information 61, an encoding strategy (code 1, code 2,code 6) and mapping strategy (map point 1.... map point 6) can be selected in this way that, in view of the actual conditions, enables a maximum data throughput for the current modulation/demodulation method with a predetermined dependability.

40 The device 29 can be arranged both in the receiver 12 as well as in the transmitter 10. In any case, either the identified signal-to-noise ratio 28 or the identified maximum transmission data rate or ~~[, respectively,]~~ the selected encoding and mapping method 30 must be transmitted to the transmitter via a data connection 31.

41 The information about the encoding and mapping method with which a maximum transmission data rate 30 can be achieved for the current modulation/demodulation method is supplied to a ~~[control means]~~ **controller** 33 in the transmitter. On the basis of the maximally possible data transmission rate and the data transmission rate 32 respectively required for the transmission of digital information 13, this control device selects an actually employed data transmission rate 34 that is to be realized by an encoding, mapping and modulation strategy to be defined. This information data rate, on the one hand, and/or encoding, mapping and modulation method on the other hand is conducted both to the corresponding components of the channel encoder 14 of the transmitter 10 such as **the** encoder 50, bit/symbol converter 15 and modulator 17, as well as via a data connection 35 to the corresponding components of the channel decoder 20 of the receiver 12 such as **the** demodulator 55, symbol/bit converter 24 and decoder 52.

42 The operation of the inventive apparatus upon system start of a transmission system is described below. The measuring of a transmission system is meaningfully implemented with the lowest possible transmission data rate (with reference to the respective modulation method) and with the maximally possible transmission power. ~~[In this way,]~~ **This assures** a low symbol error rate ~~[is assured, this being,]~~ **which is** a prerequisite for a high quality of a receiver-side signal-to-noise ratio measurement. In this case, the generally utilized adaptive methods for signal editing also exhibit the shortest transient times, and an optimally ~~[great]~~ **large** system range is achieved

with reference to a maximally allowable error rate. For defining the encoding and mapping method that allows a maximally possible transmission data rate for the transmission channel (and the momentarily utilized modulation method), only a single measurement is then required.

5 **43** When, however, the desired data rate is to be enabled over different modulation methods, then a measuring procedure must be implemented for each possible modulation strategy.

44 The operation of the inventive transmission system during system operation is described below. Advantageously, the measurement of the transmission channel
10 ensues online based on the transmitted data stream. A lowering of the net transmission data rate for realizing a transmission channel measurement ensuing outside of the payload data is therefore not required. The measuring of the signal-to-noise ratio of a transmission data rate that is actually employed suffices in order to be able to evaluate the transmission quality even with transmission data rates
15 realized with the assistance of different encoding or~~[, respectively,]~~ mapping rules. ~~[In advance,]~~ **The system can,** therefore, ~~[the system can]~~ **in advance,** also evaluate the transmission properties of other transmission data rates on the basis of the signal-to-noise ratio measurement implemented with a current data transmission rate. A repeated, iterative measurement for different transmission data rates is no
20 longer required insofar as the modulation method is not modified.

45 As long as a transmission data rate is modified only on the basis of a new encoding rule or~~[, respectively,]~~ mapping rule and not on the basis of a modified modulation method, the adaptive methods utilized in the demodulator also remain in the steady state. A change of the data rate is therefore possible interruption-free
25 (“soft switching”). When, however, the adaptation of the data rate is realized via a change of the modulation strategy, then the system must be measured anew and a “soft switching” is not possible.

46 Fig. 2 describes an embodiment ~~[wherein]~~ **in which** the maximally possible transmission data rate is determined by a receiver-side determination of the signal-to-noise ratio, and this maximally possible transmission data rate is communicated to
30 the transmission side that in turn defines an actually employed transmission data rate on the basis of the requested and the maximally possible transmission data rate and forwards this to the corresponding components in the transmitter and receiver.

In contrast ~~[thereto]~~, Fig. 3 describes an exemplary embodiment that additionally implements a control of the output power of the transmitter. The adaptation of the transmission power to the channel and to the requested transmission method is referred to below as "power control". Insofar as Fig. 3 comprises the same devices as in Fig. 2, these are provided with the same reference characters. In this embodiment, the evaluation of the transmission quality 28 of the transmission channel 11 determined at the receiver side occurs at the transmitter side. To this end, the transmitter comprises a device 41 that, like the device 29 of Fig. 2, determines an encoding strategy or~~[, respectively,]~~ a maximum transmission data rate of the transmission channel 11.

47 In addition to the transmission quality 28 determined by the receiver 12 and that is forwarded to the transmitter via the data connection 40, the device 41 also receives the data rate 32 required for the transmission of the digital information 13. An encoding or~~[, respectively,]~~ mapping and modulation method having an actual transmission data rate 34 is selected on the basis of the respectively maximally permitted error rate for the transmission of the respective digital information 13. This selected transmission data rate 34, as in the embodiment described with reference to Fig. 2, is forwarded to the channel encoder 14 and to the channel decoder 20.

48 The signal values 44 generated by the modulator 14 are additionally forwarded in the transmitter 10 to a device 43 for regulating the transmission power. The signal 45 generated by the device 43 is subsequently transmitted via the transmission channel 11. The device 41 also determines the transmission power that is minimally required for the transmission. The identified transmission power is supplied to the transmission signal amplifier 43 via a transmission power signal 42.

~~[Dependent]~~ **49** **Depending** on the difference between a measured transmission quality 46 of the transmission channel 11 and a transmission quality 47 that corresponds to the selected encoding or~~[, respectively,]~~ mapping and modulation method (with a transmission data rate 34 and with a specific maximally allowed error rate~~)))~~), an adaptation of the transmission power of the transmission signal amplifier 43 is effected. I.e., when the identified transmission signal quality of the transmission channel 46 lies above the required transmission quality 47, the transmission power is correspondingly reduced. When the required transmission

quality 47 lies above the transmission quality of the transmitter, then the transmission power must be raised.

50 In this second embodiment, thus, the difference from measured signal-to-noise ratio 46 and the signal-to-noise ratio 47 needed for the realization of a specific transmission data rate is a criterion for the boosting or~~[, respectively,]~~ lowering of the momentary transmission signal power. When the transmission power needed for the realization of a specific transmission data rate cannot be produced by the transmission module, then the transmission system can at best realize the momentarily maximally possible transmission data rate as transmission data rate.

51 Such an inventive system for adapting a transmission system to the transmission channel employed is particularly suitable for employment of the "asymmetric digital subscriber line" technology~~[. This, which is referred to as ADSL technology,]~~ **(ADSL technology)**. **This**, like other XDSL technologies, makes traditional copper telephone lines compatible as high-speed servers for data-intensive applications. At the same time, the availability of the customary telephone voice services is preserved on the same line. Based on cabling that is already present, such technologies make data rates available that, for example, exceed ISDN many times over. The limitations of the existing public information network are thus overcome, this having been ~~[hitherto]~~ **previously** suitable only for the transmission of voice, text and graphics with low resolution. With such technologies, the traditional copper cable telephone networks becomes a high-performance system that is suitable for the transmission of multi-~~[medium]~~ **media** contents to all households.

52 By employing the traditional telephone lines, however, a high noise part is accepted, this ~~[becoming all the higher the greater the]~~ **being proportional to the bridging** distance ~~[to be bridged becomes]~~. The distance to be bridged in such technologies averages between 500 and 6 km. The noise part, however, increases not only with increasing length but also due to cross-talk from neighboring lines. With the assistance of the inventive, adaptive measurement and adaptation, the transmission system can be automatically adapted with such a method to the quality of the existing transmission line.

~~[Abstract]~~ **53 The above-described method and apparatus are illustrative of the principles of the present invention. Numerous modifications and adaptations**

will be readily apparent to those skilled in this art without departing from the spirit and scope of the present invention.

~~[Method and Apparatus for Adapting a Transmission Data Rate or a Transmission Power to the Transmission Quality of a Transmission Channel]~~ **ABSTRACT**

- 5 **54** For adapting a transmission data rate to an existing transmission channel, the transmission power and/or the encoding method is inventively selected such that a maximally possible transmission data rate or~~[, respectively,]~~ minimum transmission power can be employed ~~[dependent]~~ **depending** on the transmission quality of the transmission channel.
- ~~[Figure 2]~~

This redlined draft, generated by CompareRite (TM) - The Instant Redliner, shows the differences between -

original document : Q:\DOCUMENTS\YEAR 2001\P010087-EICHINGER-ADAPTING TRANSMISSION RATE\ORIGINAL SPECIFICATION.DOC
5 and revised document: Q:\DOCUMENTS\YEAR 2001\P010087-EICHINGER-ADAPTING TRANSMISSION RATE\SUBSTITUTE SPECIFICATION.DOC

CompareRite found 184 change(s) in the text

- 10 Deletions appear as Overstrike text surrounded by []
Additions appear as Bold-Underline text

SPECIFICATION

TITLE

- 15 METHOD AND APPARATUS FOR ADAPTING A TRANSMISSION POWER TO
THE TRANSMISSION QUALITY OF A TRANSMISSION CHANNEL

BACKGROUND OF THE INVENTION

Field of the Invention

- 1 The invention is directed to a method for adapting transmission power to the
20 transmission quality of a transmission channel.

Description of the Related Art

- 2 The need for digital transmission systems has exponentially risen in recent
decades. Digital transmission systems are generally classified into the function units
25 shown in Fig. 1. A message source 1 generates information that a transmitter
transmits to a receiver via a transmission channel 4. The properties of the
information to be transmitted are dependent on the message source. Messages to
be transmitted can, for example, be an audio signal or a video signal. Analog
transmission systems ~~[thereby]~~ transmit analog signals that were generated by
30 analog message sources directly via the transmission channel upon employment of
traditional analog modulation methods. Such modulation methods are, for example,
amplitude modulation, frequency modulation or phase modulation. In digital
transmission systems, the information to be transmitted is converted into a sequence
of binary numbers. In order to be able to utilize the capacity of the channel optimally
35 ~~[well]~~, the message to be transmitted ~~[should be]~~ **is** represented with as few binary
numbers as necessary. To this end, a source encoder is employed that ~~[has the job
of converting]~~ **converts** the messages to be transmitted into sequences of signal

media. Such channels cannot directly transmit the sequence of binary numbers from the transmitter. To that end, the sequence of digital information must be converted into signal values that correspond to the properties of the channel by a device called a digital modulator. Such a modulator is part of the channel encoder 3, which additionally comprises a discrete channel encoder in order to provide the information to be transmitted with an error protection adapted to the channel.

4 The transmission channel 4 is not assumed to work error-free; rather, it is assumed that a noise source 5 will modify the transmitted signals during the transmission with a specific probability.

5 Such disturbances can, for example, be a cross-talk of signals that are transmitted on neighboring channels. The disturbances can likewise be caused by thermal noise that is generated in the electronic circuit such as amplifiers and filters that are employed in the transmitter and in the receiver. Given line connections, disturbances can additionally be caused by switching and can be additionally caused by meteorological influences given radio or satellite connections such as thunderstorms, hail or snow. Such influences modify the transmitted signal and cause errors in the received digital signal sequence.

6 In order to nonetheless assure a relatively dependable transmission, the channel encoder increases the redundancy of the (binary) sequence to be transmitted. With the assistance of this redundancy added by the transmitter, the receiver is assisted in the decoding of the information-carrying signal sequence. To this end, for example, the channel encoder combines a specific plurality of signals to form blocks and a plurality of check signals (one parity bit in the simplest case) is added. In this way, k information bits are always simultaneously encoded, where each k bit sequence has an unambiguous n bit sequence (the "code word") allocated to it. The redundancy added in this way can be indicated with the ratio n/k . This likewise corresponds to the channel bandwidth that must be correspondingly increased in order to transmit the information sequence expanded by the added redundancy.

7 Alternatively, an enhanced dependability against channel disturbances can also be achieved by, for example, an increase in the transmission power. Since the

increase in the transmission power, however, is relatively expensive, the dependability is usually achieved given available bandwidth by increasing the required channel bandwidth.

8 International patent document WO 97/03403 discloses a data transmission
5 with variable data rate in a cellular radio system. Before data are transmitted via a transmission channel, they usually pass through two encoding units, namely a voice encoding and a channel encoding. The voice encoding reduces the quantity of data required for the transmission of a specific information. The channel encoding attaches further data to the data encoded in this way in order to also assure a
10 dependable transmission given a disturbed channel. Effective voice encoding methods supply a data stream with a variable data rate dependent on the information to be encoded. Such a saving of data can usually not be directly used for other data transmissions in mobile radiotelephony. The data saved by the effective voice encoding are therefore used in order to lower the transmission power
15 of the transmitter.

9 In the transmission of one bit with the data rate R bit/s, the modulator always allocates a signal curve or a signal value (referred to below only as "signal value") $s_1(t)$ to the binary number 0 and allocates a signal value $s_2(t)$ to the binary number 1. This transmission of each individual bit by the channel encoder is called binary
20 modulation. Alternatively, the modulator can simultaneously transmit k information bits upon employment of $M = 2^k$ different signal values $s_i(t)$ with $i = 1, 2, \dots, M$, where each of the 2^k possible k -bit sequences is allocated to a signal value.

10 At the receiver side of a digital transmission system, the digital demodulator processes the signal value transmitted in the channel (potentially modified) and
25 allocates an individual number to each signal value that represents an estimate of the transmitted data symbol (for example, binary).

11 After reception of a signal in the receiver, the demodulator must decide which of the M possible signal values was sent. This decision is implemented in a decision unit (slicer) in which the decision is made with a minimal error probability. This
30 decision unit allocates a reception value (usually edited) to one of the M possible symbol values.

12 When, for example, a binary modulation is employed, the demodulator must
decide when processing each received signal whether the transmitted bit is a 0 or a
1. In this case, the demodulator implements a binary decision. Alternatively, the
demodulator can also implement a ternary decision, whereby the demodulator
5 decides for "0", "1" or "no decision" depending on the quality of the received signal.

13 The decision process of a demodulator can be viewed as quantization, where
binary and ternary decisions are specific instances of a demodulation that quantizes
the Q-level, where $Q \geq 2$ applies. In general, digital communication systems employ a
high-order modulation, where $m = 0, 1 \dots M-1$ represents the possible transmitted
10 symbols.

14 When the transmitted information contains no redundancy, the demodulator
must decide at every predetermined time interval which of the M-signal values was
transmitted. When the transmitted information, in contrast, contains redundancy,
then the demodulator reconstructs the original information sequence on the basis of
15 the code employed by the channel encoder and on the basis of the redundancy of
the received signals. Dependent on the demands defined by the applications, the
channel encoder generates signal blocks that make it possible for the channel
decoder to either only identify where the specific disturbances have occurred (error-
recognizing encoding) or to even be able to automatically correct (error-correcting
20 encoding) errors caused by disturbances (up to a specific maximum number per
signal block).

15 One criterion for the dependability with which the messages are transmitted
from the transmitter to the receiver is represented by the error rate. The error rate
indicates the average probability with which a bit error occurs at the output of the
25 decoder. The bit error rate indicates the number of error bits occurring at the
receiver divided by the total number of received bits per time unit. The bit error rate
(or symbol error rate when the error frequency of symbols is evaluated) is the most
important quality criterion of a digital transmission system. In general, the error
probability is dependent on the code properties, on the nature of the signal values
30 employed for the transmission of the information via the channel, on the
transmission power, on the properties of the channel, i.e., the strength of the noise,

the type of noise, etc., and on the demodulation and decoding method. The significance of the bit error rate for digital transmission systems corresponds to the signal-to-noise ration (SNR) of analog transmission systems.

16 The error rates with which symbols occur at the output of the demodulator or
5 with which bits occur at the output of the decoder are dependent on the properties of the transmission medium, i.e., of the transmission channel, on the selected modulation and encoding strategy and on the average power of the transmission signal. For adaptation of a transmission data rate to a transmission channel, the transmission properties of the transmission channel are traditionally determined by
10 communicating a bit or symbol sequence that is known to the receiver. The error rate of the channel can be determined on the basis of a rated-actual comparison in the receiver. In this way, the quality of the current data transmission can be identified. What is disadvantageous about this method, however, is that only the measurement of a possible combination of transmission power, encoding method
15 and modulation method can be measured. So that a separate measurement need not be implemented for every possible data rate or transmission power, iterative methods are usually utilized for finding an optimum transmission data rate or transmission power.

17 United Kingdom patent GB-A-2303769 discloses communication equipment
20 that is in the position of setting the transmission data rate. First, a transmission data rate is selected dependent on the measured electrical field strength. This transmission data rate is subsequently additionally varied dependent on a measured bit error rate, namely, reduced given a high error rate and boosted given a low error rate. The bit error rate measurement serves as the basis for a fine adjustment of the
25 transmission data rate.

SUMMARY OF THE INVENTION

18 An object of the invention is to create an improved method and an improved apparatus for adapting the transmission power to the transmission channel.

30 19 This object is achieved by an apparatus for setting transmission power for the transmission of digital information, comprising a transmission channel via which the

digital information is transmitted; a controller for boosting or reducing the transmission power; and a quality meter for communicating a determined transmission quality of the transmission channel; the controller setting the transmission power for a transmission of digital information dependent on a difference between a metered transmission quality determined by the quality meter and a required transmission quality that is required for a transmission data rate employed for the transmission of the digital information with a specific, maximally allowed error rate.

20 This object is also achieved by a method for setting a transmission power for a transmission of digital information via a transmission channel, comprising the steps of: measuring an identified transmission quality; determining a difference between the identified transmission quality and a required transmission quality that is required for a defined transmission data rate employed for the transmission of digital information with a specific, maximally allowed error rate; and boosting or lowering the transmission power for the transmission of digital information depending on the difference.

21 Inventively, a transmission power is set dependent on the measured transmission quality of the transmission channel. With the measurement of the transmission quality, particularly with a receiver-side determination of the signal-to-noise ratio based on the received signals, the transmission power can be minimized depending on the transmission data rate employed.

22 In this way, the transmission sequence of modulator/transmission channel/demodulator can be measured on line (i.e., during the data transmission) independently of the selected encoding method, and the transmission power can be set such dependent on the required data transmission rate that a predetermined bit or symbol error rate is guaranteed. The measurement of the transmission quality is a prerequisite in order to define the minimum transmission power for a defined transmission rate such that a maximally acceptable error rate is not exceeded.

23 The power of the transmitter can be adapted to the required transmission quality in that the transmission power is raised or lowered dependent on a difference between a measured signal-to-noise ratio and a required signal-to-noise ratio. In

this way, the transmission power, based on a measurement of the signal-to-noise ratio, can be optimally adapted, i.e., minimized, to the selected transmission method and the existing transmission channel, i.e., the lowest possible transmission power given simultaneous assurance of the quality demands and adherence to the required transmission rate. The noise emissions are thus minimized and, at the same time, the transmission capacity of neighboring systems that work on the same frequency band is increased.

24 Advantageous developments for the apparatus include providing a definition mechanism for defining a maximum transmission data rate of said transmission channel depending on said determined transmission quality. The apparatus may further comprise a connection with which a definition mechanism for determining a maximum transmission data rate is supplied with a predetermined, maximally allowed error rate. Also, a selector for selecting a transmission data rate dependent on a maximum transmission data rate determined by said definition mechanism and dependent on a specific, requested transmission data rate can be provided. The apparatus may also include a transmitter for said transmission of digital information via said transmission channel, said transmitter comprising: a digital channel encoding device for encoding said digital information; a bit/symbol converter for presentation of said digital information in a form of symbols; and a modulator for mapping said symbols onto signal values for transmission via said transmission channel; said apparatus further comprising: a receiver, comprising: a demodulator for converting received signal values into detected symbols; a symbol/bit converter for converting said detected symbols as a received symbol stream into an encoded bit stream; and a decoder for presentation of said detected symbols as detected digital information.

25 The inventive method may further comprise the step of defining a maximum transmission data rate of said transmission channel dependent on said identified transmission quality and on a modulation method employed. A step of defining said maximum transmission data rate dependent on a specific, maximally allowed error rate may also be provided. The method may also provide a step of transmitting said digital information which comprises the steps of: presenting said digital information in

a form of symbols; mapping said symbols onto signal values; transmitting said signal values via said transmission channel; receiving said transmitted signal values; detecting said received signal values; mapping said detected signal values onto detected symbols; and converting said detected symbols into a detected digital information. Further steps may be provided, including defining a signal-to-noise ratio based on signal values received at a receiver side as a criterion for said transmission quality; determining said transmission quality of said transmission channel; and defining a maximum transmission data rate of said transmission channel depending on said identified transmission quality and on said modulation method employed. The inventive method may also include the step of selecting a transmission data rate, a mapping algorithm, and a corresponding encoding method depending on said maximum transmission data rate of the transmission channel determined by a definition mechanism and depending on a requested transmission data rate and a maximally acceptable error rate. A further embodiment of the inventive method may include the steps of: determining a transmission quality for different respective modulation methods; defining a maximally possible data rate of said transmission channel for each modulation method; and selecting a modulation method to be employed depending on said maximally possible data rate determined for each modulation method. Finally, the inventive method may involve a step of boosting or lowering a transmission power for said transmission of digital information via said transmission channel depending on a difference between said identified transmission quality and said required transmission quality that is required for a defined transmission data rate employed for the transmission of the digital information with a specific, maximally allowed error rate.

BRIEF DESCRIPTION OF THE DRAWINGS

Preferred exemplary embodiments of the invention are explained below on the basis of the drawing.

Fig. 1 is a block diagram illustrating the general structure of a message transmission system;

Fig. 2 is a block schematic diagram illustrating the structure of an inventive

transmission system for adapting the data rate and the modulation method to the transmission medium on the basis of receiver-side signal-to-noise ratio measurement;

Fig. 3 is a block schematic diagram illustrating the structure of an inventive transmission system for adapting the transmission data rate, the modulation method and the transmission power to the transmission medium on the basis of receiver-side signal-to-noise ratio measurement; and

Fig. 4 is a graph illustrating the "power control" for setting a transmission power dependent on a measure and on an employed transmission quality.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

27 In digital information transmission, information are transmitted between a message source (transmitter) and a receiver via a transmission medium. Such an apparatus that is located between the transmitter and the receiver is generally referred to as a channel.

28 For the transmission, the data to be transmitted are converted into code words that are matched to the transmission properties of the message channel in order to protect the data to be transmitted against among other things, transmission errors.

29 In the transmission, a character, which is generally referred to as a symbol in the signal space or channel symbol, is allocated to a bit sequence with a reversibly unambiguous, functional allocation. This symbol is subsequently mapped onto a signal curve (referred to below as a "signal value"). The functional allocation of a symbol to a bit sequence in the transmitter is called encoding or mapping; the mapping of such a symbol or of a plurality of such symbols onto a signal value is called modulation.

30 The reversal of this mapping sequence occurs in the receiver. Whereas the demodulation, i.e., the allocation of a reception signal to a symbol, can usually not be implemented error-free due to distortions or superimposed disturbances of the

channel, the decoding, i.e., the conversion of a detected symbol into the corresponding bit sequence, does not suffer from similar difficulties.

31 Fig. 2 shows the structure of a transmission system that sets a desired data rate after determination of the quality of the transmission channel.

5 Digital information, particularly a bit sequence 13, is transmitted to a receiver 12 from a transmitter 10 via a transmission channel 11, the receiver 12 outputting the received digital information, particularly the bit sequence 25. The channel encoder 14 of the transmitter 10 contains a digital channel encoder 50, a bit/symbol converter 15 and a modulator 17. The digital channel encoder 50 adds redundancy to the
10 incoming bit stream 13. The encoded bit stream 51 formed in this way is converted into a symbol sequence 16 in the bit/symbol converter 15, this symbol sequence 16 being in turn reversibly unambiguously mapped by a modulator 17 onto a signal curve or signal values 18. The signal values 18 are transmitted via the transmission channel 11 to the receiver 12.

15 32 The channel decoder 20 of the receiver 12, which converts the received signal values 19 into a digital information 25, contains a demodulator 55, a symbol/bit converter 24 and a digital channel decoder 52 as critical components. In the demodulator, the received signal values 19 are initially edited by an analog and optional digital signal processing unit that, for example, could contain a reception
20 amplifier, an analog-to-digital conversion, and a distortion correction means. The signal values 21 edited in this way are subsequently supplied to a decision unit slicer 22 that allocates a symbol 23 to every received signal value 21.

33 The symbol/bit converter 24 of the channel decoder 20 allocates and encodes digital information or an encoded bit sequence 53 to each detected symbol or each
25 detected symbol sequence 23 according to the selected mapping method. The digital information or the bit stream 25 is derived from the digital information/encoded bit sequence 53 with the assistance of the digital channel decoder 52 according to the selected encoding method.

34 The decision unit (slicer) 22 is a basic component part of every demodulator.

30 Such a decision unit allocates the symbol(s) that was most probably sent to the receiver - usually edited. Since the set of input values of the decision unit, due to

disturbances or distortions of the transmission channel, usually does not correspond to the "valid" signal values of the transmitter, i.e., the signal values that are allocated to the symbols to be transmitted, the signal-to-noise ratio 28 adjacent to the decision input can be determined from the input signal 21 and the output signal 23 of the

5 decision unit independently of the encoding and mapping algorithm employed. To this end, an inventive receiver comprises a device 27 for measuring the signal-to-noise ratio (SNR) of the information transmitted via the transmission channel 11.

35 In a possible embodiment of a device for measuring the signal-to-noise ratio, a signal value 60 that the input of the decision unit in the demodulator would have received if the signal curve signal value corresponding to the detected symbol had been transmitted reliably is again allocated to every detected symbol in the

10 demodulator at the receiver side. In this way, a hypothetical input signal is formed corresponding to the detected symbol values that contains no signal values with channel distortions or disturbances. This reference signal - as long as the decision unit does not detect any incorrect symbols - thus corresponds to the original signal at the transmitter side. By subtracting this reference signal from the edited receiver signal 21, the noise signal can be acquired.

36 The average power of this reference signal formed in this way corresponds to the average power of the received undisturbed signal part. The average power of the signal adjacent at the input of the decision unit corresponds to the aggregate

20 power of received noise and signal part. The noise power is calculated from this with the assistance of the previously calculated, undisturbed signal part. The signal-to-noise ratio (SNR) as a criterion for the transmission quality of the transmission channel derives from the ratio of the average power of the undisturbed signal part to

25 the average power of the noise part.

37 What such a method avoids is that the receiver must know a specific transmission sequence, as necessary given other, traditional methods. Moreover, the determination of the error rate ensues in parallel to the evaluation of the transmitted symbols, i.e., online. A periodic introduction of a test sequence into the

30 data stream to be transmitted is therefore no longer required for the continuous measurement of the transmission quality. This avoids a reduction of the net data

rate of the transmission channel.

38 In order to assure a high statistical dependability, a traditional method that employs a test sequence known to the transmitter and receiver must cover a great number of errors, usually several hundred. The traditional methods require very
5 long measuring times in order to detect a corresponding plurality of errors for the very low bit error rates of, for example, 10^9 that are generally required. The inventive method, in contrast, is based on the interpretation of the measured signal-to-noise ratio during ongoing transmission. Since, however, significantly shorter measuring times are required for the interpretation of the average powers when compared to
10 the comparable interpretation of the symbol or bit stream, the transmission quality can be determined far faster with the inventive method.

39 Depending on the selected encoding and mapping method, there is always an unambiguous functional relationship between the signal-to-noise ratio 28 and a symbol error rate or bit error rate. The signal-to-noise ratio thus qualifies the
15 transmission properties of the channel and of the momentarily selected modulation or demodulation method independently of the selected encoding or mapping method. Via a measurement of the signal-to-noise ration 28 of a transmission channel 11, thus, the encoding or the mapping method of the current modulation/demodulation method can be defined such that a desired data
20 throughput can be set for an error rate that can just be accepted. To this end, the identified signal-to-noise ratio 28 is supplied to a device/definition mechanism 29 for determining a maximum transmission data rate 30 or an encoding and mapping method. Depending on the signal-to-noise ratio 28, preferably determined in decibels (dB) according to a known relationship, the device 29 defines an encoding
25 and mapping method or a maximum transmission data rate 30 for the current modulation and demodulation method that enables a maximum data throughput given the existing signal-to-noise ratio 28. The maximally acceptable error rate 61 and of the modulation method/strategy 62 appear as parameters of the conversion characteristic of the device 29. Depending on the measured transmission quality 28
30 of the transmission channel 11 and depending on the current modulation/demodulation method 62 and depending on a maximally allowed error

rate in the transmission of the digital information 61, an encoding strategy (code 1, code 2,code 6) and mapping strategy (map point 1.... map point 6) can be selected in this way that, in view of the actual conditions, enables a maximum data throughput for the current modulation/demodulation method with a predetermined dependability.

40 The device 29 can be arranged both in the receiver 12 as well as in the transmitter 10. In any case, either the identified signal-to-noise ratio 28 or the identified maximum transmission data rate or the selected encoding and mapping method 30 must be transmitted to the transmitter via a data connection 31.

41 The information about the encoding and mapping method with which a maximum transmission data rate 30 can be achieved for the current modulation/demodulation method is supplied to a controller 33 in the transmitter. On the basis of the maximally possible data transmission rate and the data transmission rate 32 respectively required for the transmission of digital information 13, this control device selects an actually employed data transmission rate 34 that is to be realized by an encoding, mapping and modulation strategy to be defined. This information data rate, on the one hand, and/or encoding, mapping and modulation method on the other hand is conducted both to the corresponding components of the channel encoder 14 of the transmitter 10 such as the encoder 50, bit/symbol converter 15 and modulator 17, as well as via a data connection 35 to the corresponding components of the channel decoder 20 of the receiver 12 such as the demodulator 55, symbol/bit converter 24 and decoder 52.

42 The operation of the inventive apparatus upon system start of a transmission system is described below. The measuring of a transmission system is meaningfully implemented with the lowest possible transmission data rate (with reference to the respective modulation method) and with the maximally possible transmission power. This assures a low symbol error rate, which is a prerequisite for a high quality of a receiver-side signal-to-noise ratio measurement. In this case, the generally utilized adaptive methods for signal editing also exhibit the shortest transient times, and an optimally large system range is achieved with reference to a maximally allowable error rate. For defining the encoding and mapping method that allows a maximally

possible transmission data rate for the transmission channel (and the momentarily utilized modulation method), only a single measurement is then required.

43 When, however, the desired data rate is to be enabled over different modulation methods, then a measuring procedure must be implemented for each possible modulation strategy.

44 The operation of the inventive transmission system during system operation is described below. Advantageously, the measurement of the transmission channel ensues online based on the transmitted data stream. A lowering of the net transmission data rate for realizing a transmission channel measurement ensuing outside of the payload data is therefore not required. The measuring of the signal-to-noise ratio of a transmission data rate that is actually employed suffices in order to be able to evaluate the transmission quality even with transmission data rates realized with the assistance of different encoding or mapping rules. The system can, therefore, in advance, also evaluate the transmission properties of other transmission data rates on the basis of the signal-to-noise ratio measurement implemented with a current data transmission rate. A repeated, iterative measurement for different transmission data rates is no longer required insofar as the modulation method is not modified.

45 As long as a transmission data rate is modified only on the basis of a new encoding rule or mapping rule and not on the basis of a modified modulation method, the adaptive methods utilized in the demodulator also remain in the steady state. A change of the data rate is therefore possible interruption-free ("soft switching"). When, however, the adaptation of the data rate is realized via a change of the modulation strategy, then the system must be measured anew and a "soft switching" is not possible.

46 Fig. 2 describes an embodiment in which the maximally possible transmission data rate is determined by a receiver-side determination of the signal-to-noise ratio, and this maximally possible transmission data rate is communicated to the transmission side that in turn defines an actually employed transmission data rate on the basis of the requested and the maximally possible transmission data rate and forwards this to the corresponding components in the transmitter and receiver. In

contrast, Fig. 3 describes an exemplary embodiment that additionally implements a control of the output power of the transmitter. The adaptation of the transmission power to the channel and to the requested transmission method is referred to below as "power control". Insofar as Fig. 3 comprises the same devices as in Fig. 2, these are provided with the same reference characters. In this embodiment, the evaluation of the transmission quality 28 of the transmission channel 11 determined at the receiver side occurs at the transmitter side. To this end, the transmitter comprises a device 41 that, like the device 29 of Fig. 2, determines an encoding strategy or a maximum transmission data rate of the transmission channel 11.

47 In addition to the transmission quality 28 determined by the receiver 12 and that is forwarded to the transmitter via the data connection 40, the device 41 also receives the data rate 32 required for the transmission of the digital information 13. An encoding or mapping and modulation method having an actual transmission data rate 34 is selected on the basis of the respectively maximally permitted error rate for the transmission of the respective digital information 13. This selected transmission data rate 34, as in the embodiment described with reference to Fig. 2, is forwarded to the channel encoder 14 and to the channel decoder 20.

48 The signal values 44 generated by the modulator 14 are additionally forwarded in the transmitter 10 to a device 43 for regulating the transmission power.

49 The signal 45 generated by the device 43 is subsequently transmitted via the transmission channel 11. The device 41 also determines the transmission power that is minimally required for the transmission. The identified transmission power is supplied to the transmission signal amplifier 43 via a transmission power signal 42.

50 Depending on the difference between a measured transmission quality 46 of the transmission channel 11 and a transmission quality 47 that corresponds to the selected encoding or mapping and modulation method (with a transmission data rate 34 and with a specific maximally allowed error rate), an adaptation of the transmission power of the transmission signal amplifier 43 is effected. I.e., when the identified transmission signal quality of the transmission channel 46 lies above the required transmission quality 47, the transmission power is correspondingly reduced.

When the required transmission quality 47 lies above the transmission quality of the transmitter, then the transmission power must be raised.

50 In this second embodiment, thus, the difference from measured signal-to-noise ratio 46 and the signal-to-noise ratio 47 needed for the realization of a specific transmission data rate is a criterion for the boosting or lowering of the momentary transmission signal power. When the transmission power needed for the realization of a specific transmission data rate cannot be produced by the transmission module, then the transmission system can at best realize the momentarily maximally possible transmission data rate as transmission data rate.

51 Such an inventive system for adapting a transmission system to the transmission channel employed is particularly suitable for employment of the "asymmetric digital subscriber line" technology (ADSL technology). This, like other XDSL technologies, makes traditional copper telephone lines compatible as high-speed servers for data-intensive applications. At the same time, the availability of the customary telephone voice services is preserved on the same line. Based on cabling that is already present, such technologies make data rates available that, for example, exceed ISDN many times over. The limitations of the existing public information network are thus overcome, this having been previously suitable only for the transmission of voice, text and graphics with low resolution. With such technologies, the traditional copper cable telephone networks becomes a high-performance system that is suitable for the transmission of multi-media contents to all households.

52 By employing the traditional telephone lines, however, a high noise part is accepted, this being proportional to the bridging distance. The distance to be bridged in such technologies averages between 500 and 6 km. The noise part, however, increases not only with increasing length but also due to cross-talk from neighboring lines. With the assistance of the inventive, adaptive measurement and adaptation, the transmission system can be automatically adapted with such a method to the quality of the existing transmission line.

53 The above-described method and apparatus are illustrative of the principles of the present invention. Numerous modifications and adaptations will be readily

apparent to those skilled in this art without departing from the spirit and scope of the present invention.

ABSTRACT

54 For adapting a transmission data rate to an existing transmission channel, the
transmission power and/or the encoding method is inventively selected such that a
maximally possible transmission data rate or minimum transmission power can be
5 employed depending on the transmission quality of the transmission channel.

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**METHOD AND APPARATUS FOR ADAPTING A TRANSMISSION DATA
RATE OR A TRANSMISSION POWER TO THE TRANSMISSION QUALITY
OF A TRANSMISSION CHANNEL**

The invention is directed to a method for adapting a transmission data rate
5 or transmission power to the transmission quality of a transmission channel.

The need for digital transmission systems has exponentially risen in recent
decades. Digital transmission systems are generally classified into the function units
shown in Fig. 1. A message source 1 generates information that a transmitter
transmits to a receiver via a transmission channel 4. The properties of the information
10 to be transmitted are dependent on the message source. Messages to be transmitted
can, for example, be an audio signal or a video signal. Analog transmission systems
thereby transmit analog signals that were generated by analog message sources
directly via the transmission channel upon employment of traditional analog
modulation methods. Such modulation methods are, for example, amplitude
15 modulation, frequency modulation or phase modulation. In digital transmission
systems, the information to be transmitted is converted into a sequence of binary
numbers. In order to be able to utilize the capacity of the channel optimally well, the
message to be transmitted should be represented with as few binary numbers as
necessary. To this end, a source encoder is employed that has the job of converting
20 the messages to be transmitted into sequences of signal values and encoding them, so
that the channel can transmit them. The source encoder thereby attempts to convert
the messages to be transmitted into binary numerals as efficiently as possible.

The sequence of binary numbers generated by the source encoder is
transmitted by the channel to the receiver. Such an actual channel can, for example,
25 be composed of a line connection, of a coaxial cable, of a light waveguide (LWL), of
a radio connection, a satellite channel or a combination of these transmission media.
Such channels cannot directly transmit the sequence of binary numbers from the
transmitter. To that end, the sequence of digital information must be converted into
signal values that correspond to the properties of the channel. Such a device is called
30 a digital modulator. Such a modulator is part of the channel encoder 3, which

additionally comprises a discrete channel encoder in order to provide the information to be transmitted with an error protection adapted to the channel.

It is not assumed of the transmission channel 4 that it works error-free; rather, it is assumed that a noise source 5 will modify the transmitted signals during the transmission with a specific probability.

Such disturbances can, for example, be a cross-talk of signals that are transmitted on neighboring channels. The disturbances can likewise be caused by thermal noise that is generated in the electronic circuit such as, for example, amplifiers and filters that are employed in the transmitter and in the receiver. Given line connections, disturbances can additionally be caused by switchings and can be additionally caused by meteorological influences given radio or satellite connections such as, for example, thunderstorms, hail or snow. Such influences modify the transmitted signal and cause errors in the received digital signal sequence.

In order to nonetheless assure a relatively dependable transmission, the channel encoder increases the redundancy of the (binary) sequence to be transmitted. With the assistance of this redundancy added by the transmitter, the receiver is assisted in the decoding of the information-carrying signal sequence. To this end, for example, the channel encoder combines a specific plurality of signals to form blocks and a plurality of check signals (one parity bit in the simplest case) is added. In this way, k information bits are always simultaneously encoded, whereby each k bit sequence has an unambiguous n bit sequence, what is referred to as the code word, allocated to it. The redundancy added in this way can be indicated with the ratio n/k . This likewise corresponds to the channel bandwidth that must be correspondingly increased in order to transmit the information sequence expanded by the added redundancy.

Alternatively, an enhanced dependability against channel disturbances can also be achieved, for example, by an increase in the transmission power. Since the increase in the transmission power, however, is relatively expensive, the dependability is usually achieved given available bandwidth by increasing the required channel bandwidth.

In the transmission of one bit with the data rate R bit/s, the modulator always allocates a signal curve or, respectively, a signal value (referred to below only as signal value) $s_1(t)$ to the binary number 0 and allocates a signal value $s_2(t)$ to the binary number 1. This transmission of each individual bit by the channel encoder is
 5 called binary modulation. Alternatively, the modulator can simultaneously transmit k information bits upon employment of $M = 2^k$ different signal values $s_i(t)$ with $i = 1, 2, \dots, M$, whereby each of the 2^k possible k -bit sequences is allocated to a signal value.

At the receiver side of a digital transmission system, the digital demodulator processes the signal value transmitted in the channel (potentially
 10 modified) and allocates an individual number to each signal value that represents an estimate of the transmitted data symbol (for example, binary).

After reception of a signal in the receiver, the demodulator must decide which of the M possible signal values was sent. This decision is implemented in a decision unit (slicer), whereby the decision should be made with minimal error
 15 probability. This decision unit allocates a reception value (usually edited) to one of the M possible symbol values.

When, for example, a binary modulation is employed, the demodulator must decide when processing each received signal whether the transmitted bit is a matter of a 0 or of a 1. In this case, the demodulator implements a binary decision.
 20 Alternatively, the demodulator can also implement a ternary decision, whereby the demodulator decides for "0", "1" or "no decision" dependent on the quality of the received signal.

The decision process of a demodulator can be viewed as quantization, whereby binary and ternary decisions are specific instances of a demodulation that
 25 quantizes the Q -level, whereby $Q \geq 2$ applies. In general, digital communication systems employ a high-order modulation, whereby $m = 0, 1 \dots M-1$ represents the possible transmitted symbols.

When the transmitted information contains no redundancy, the demodulator must decide at every predetermined time interval which of the M -signal
 30 values was transmitted. When the transmitted information, in contrast, contains redundancy, then the demodulator reconstructs the original information sequence on

the basis of the code employed by the channel encoder and on the basis of the redundancy of the received signals. Dependent on the demands defined by the applications, the channel encoder generates signal blocks that make it possible for the channel decoder to either only identify where the specific disturbances have occurred (error-recognizing encoding) or to even be able to automatically correct (error-correcting encoding) errors caused by disturbances (up to a specific maximum number per signal block).

One criterion for the dependability with which the messages are transmitted from the transmitter to the receiver is represented by the error rate. The error rate indicates the average probability with which a bit error occurs at the output of the decoder. The bit error rate indicates the plurality of error bits occurring at the receiver divided by the total number of received bits per time unit. The bit error rate (or symbol error rate when the error frequency of symbols is evaluated) is the most important quality criterion of a digital transmission system. In general, the error probability is dependent on the code properties, on the nature of the signal values employed for the transmission of the information via the channel, on the transmission power, on the properties of the channel, i.e. the strength of the noise, the type of noise, etc., and on the demodulation and decoding method. The significance of the bit error rate for digital transmission systems corresponds to the signal-to-noise ration (SNR) of analog transmission systems.

The error rates with which symbols occur at the output of the demodulator or, respectively, with which bits occur at the output of the decoder are dependent on the properties of the transmission medium, i.e. of the transmission channel, on the selected modulation and encoding strategy and on the average power of the transmission signal. For adaptation of a transmission data rate to a transmission channel, the transmission properties of the transmission channel are traditionally determined by communicating a bit or, respectively, symbol sequence that is known to the receiver. The error rate of the channel can be determined on the basis of a rated-actual comparison in the receiver. In this way, the quality of the current data transmission can be identified. What is disadvantageous about this method, however, is that only the measurement of a possible combination of transmission power,

encoding method and modulation method can be measured. So that a separate measurement need not be implemented for every possible data rate or, respectively, transmission power, iterative methods are usually utilized for finding an optimum transmission data rate or, respectively, transmission power.

5 An object of the invention is to create an improved method or an improved apparatus for adapting the transmission data rate or/and the transmission power to the transmission channel.

 This object is achieved for an apparatus with the technical teaching of patent claims 1 and 9 and is achieved for a method with the technical teaching of
10 patent claims 10 and 17.

 Advantageous developments of the invention are recited in the subclaims.

 Inventively, a transmission data rate or a transmission power is set dependent on the measured signal-to-noise ratio of the transmission channel. The maximally possible data throughput can be determined with the measurement of the
15 transmission quality, particularly of the signal-to-noise ratio, of the transmission channel, and, accordingly, a transmission data rate can be defined or the transmission power can be minimized dependent on the transmission data rate employed.

 In this way, the transmission sequence of modulator/transmission channel/demodulator can be measured on line (i.e., during the data transmission)
20 independently of the selected encoding method, and the transmission power or/and the encoding method can be set such dependent on the required data transmission rate that a predetermined bit or, respectively, symbol error rate is guaranteed. The measurement of the signal-to-noise ratio is the prerequisite in order to define an encoding method that can be found for a maximally acceptable error rate of the
25 maximally possible data throughput and in order to define the minimum transmission power such for a defined transmission rate that a maximally acceptable error rate is not exceeded. It is particularly advantageous that a single measurement suffices for finding an encoding method that allows the maximally possible transmission rate with reference to the current transmission channel and the modulation method employed,
30 in contrast whereto every possible combination of transmission power, encoding and modulation method must be traditionally measured. It follows therefrom that a

change in the data rate is possible without interruption (“soft switching”) as long as the modulation strategy that is employed is retained.

Additionally, the power of the transmitter can be adapted to the required transmission quality in that the transmission power is raised or, respectively, lowered dependent on a difference between a measured signal-to-noise ratio and a required signal-to-noise ratio. In this way, the transmission power, based on a measurement of the signal-to-noise ratio, can be optimally adapted, i.e. minimized, to the selected transmission method and the existing transmission channel, i.e. lowest possible transmission power given simultaneous assurance of the quality demands and adherence to the required transmission rate. The noise emissions are thus minimized and, at the same time, the transmission capacity of neighboring systems that work on the same frequency band is increased.

Preferred exemplary embodiments of the invention are explained below on the basis of the drawing. Shown are:

- 15 Fig. 1 the general structure of a message transmission system;
- Fig. 2 the structure of an inventive transmission system for adapting the data rate and the modulation method to the transmission medium on the basis of receiver-side signal-to-noise ratio measurement.
- Fig. 3 the structure of an inventive transmission system for adapting the transmission data rate, the modulation method and the transmission power to the transmission medium on the basis of receiver-side signal-to-noise ratio measurement; and
- 20 Fig. 4 a diagram for illustrating the “power control” for setting a transmission power dependent on a measure and on an employed transmission quality.

In digital information transmission, information are transmitted between a message source (transmitter) and a receiver via a transmission medium. Such an apparatus that is located between the transmitter and the receiver is generally referred to as channel.

For the transmission, the data to be transmitted are converted into code words that are matched to the transmission properties of the message channel in order to protect the data to be transmitted against among other things, transmission errors.

In the transmission, a character, which is generally referred to as symbol in the signal space or channel symbol, is allocated to a bit sequence with a reversibly unambiguous, functional allocation. This symbol is subsequently mapped onto a signal curve (referred to below as signal value). The functional allocation of a symbol to a bit sequence in the transmitter is called encoding or mapping; the mapping of such a symbol or of a plurality of such symbols onto a signal value is called modulation.

The reversal of this mapping sequence occurs in the receiver. Whereas the demodulation, i.e. the allocation of a reception signal to a symbol, can usually not be implemented error-free due to distortions or superimposed disturbances of the channel, the decoding, i.e. the conversion of a detected symbol into the corresponding bit sequence, does not represent any problems.

Fig. 2 shows the structure of a transmission system that sets a desired data rate after determination of the quality of the quality of the transmission channel. A digital information, particularly a bit sequence 13, is transmitted to a receiver 12 from a transmitter 10 via a transmission channel 11, said receiver 12 outputting the received digital information, particularly the bit sequence 25. The channel encoder 14 of the transmitter 10 contains a digital channel encoder 50, a bit/symbol converter 15 and a modulator 17. The digital channel encoder 50 adds redundancy to the incoming bit stream 13. The encoded bit stream 51 formed in this way is converted into a symbol sequence 16 in the bit/symbol converter 15, this symbol sequence 16 being in turn reversibly unambiguously mapped by a modulator 17 onto a signal curve or, respectively, signal values 18. The signal values 18 are transmitted via the transmission channel 11 to the receiver 12.

The channel decoder 20 of the receiver 12, which converts the received signal values 19 into a digital information 25, contains a demodulator 55, a symbol/bit converter 24 and a digital channel decoder 52 as critical components. In the demodulator, the received signal values 19 are initially edited by an analog and optional digital signal processing unit that, for example, could contain a reception amplifier, an analog-to-digital conversion and a distortion correction means. The

signal values 21 edited in this way are subsequently supplied to a decision unit or, respectively slicer 22 that allocates a symbol 23 to every received signal value 21.

The symbol/bit converter 24 of the channel decoder 20 allocated and encoded, digital information or, respectively, an encoded bit sequence 53 to each
 5 detected symbol or, respectively, each detected symbol sequence 23 according to the selected mapping method, the digital information or, respectively, the bit stream 25 being derived therefrom with the assistance of the digital channel decoder 52 according to the selected encoding method.

The decision unit (slicer) 22 is a basic component part of every
 10 demodulator. Such a decision unit allocates the symbol or, respectively, the symbols that was most probably sent to the reception value - usually edited. Since the set of input values of the decision unit, due to disturbances or distortions of the transmission channel, usually does not correspond to the "valid" signal values of the transmitter, i.e. the signal values that are allocated to the symbols to be transmitted, the signal-to-
 15 noise ratio 28 adjacent to the decision input can be determined from the input signal 21 and the output signal 23 of the decision unit independently of the encoding and mapping algorithm employed. To this end, an inventive receiver comprises a device 27 for measuring the signal-to-noise ratio (SNR) of the information transmitted via the transmission channel 11.

20 In a possible embodiment of a device for measuring the signal-to-noise ratio, a signal value 60 that the input of the decision unit in the demodulator would have received if the signal curve or, respectively, signal value corresponding to the detected symbol had been transmitted unfalsified is again allocated to every detected symbol in the demodulator at the receiver side. In this way, a hypothetical input
 25 signal corresponding to the detected symbol values that contains no signal values with channel distortions or disturbances is formed. This reference signal - as long as the decision unit does not detect any incorrect symbols - thus corresponds to the original signal at the transmitter side. By subtracting this reference signal from the edited receiver signal 21, the noise signal can be acquired.

30 The average power of this reference signal formed in this way corresponds to the average power of the received undisturbed signal part. The average power of

the signal adjacent at the input of the decision unit corresponds to the aggregate power of received noise and signal part. The noise power is calculated therefrom with the assistance of the previously calculated, undisturbed signal part. The signal-to-noise ratio (SNR) as a criterion for the transmission quality of the transmission channel
 5 derives from the ratio of the average power of the undisturbed signal part to the average power of the noise part.

What such a method avoids is that the receiver must know a specific transmission sequence, as necessary given other, traditional methods. Moreover, the determination of the error rate ensues parallel to the evaluation of the transmitted
 10 symbols, i.e. online. A periodic introduction of a test sequence into the data stream to be transmitted is therefore no longer required for the continuous measurement of the transmission quality. In this way, a reduction of the net data rate of the transmission channel can be avoided.

In order to assure a high statistical dependability, a traditional method that
 15 employs a test sequence known to the transmitter and receiver must cover a great number of errors, usually several hundred. The traditional methods require very long measuring times in order to detect a corresponding plurality of errors for the very low bit error rates of, for example, 10^9 that are generally required. The inventive method, in contrast, is based on the interpretation of the measured signal-to-noise ratio during
 20 ongoing transmission. Since, however, only significantly shorter measuring times are required for the interpretation of the average powers when compared to the comparable interpretation of the symbol or, respectively, bit stream, the transmission quality can be determined far faster with the inventive method.

Dependent on the selected encoding and mapping method, there is always
 25 an unambiguous functional relationship between the signal-to-noise ratio 28 and a symbol error rate or, respectively, bit error rate. The signal-to-noise ratio thus qualifies the transmission properties of the channel and of the momentarily selected modulation or, respectively, demodulation method independently of the selected encoding or, respectively, mapping method. Via a measurement of the signal-to-noise
 30 ration 28 of a transmission channel 11, thus, the encoding or, respectively, the mapping method of the current modulation/demodulation method can be defined such

that a desired data throughput can be set for an error rate that can just be accepted. To this end, the identified signal-to-noise ratio 28 is supplied to a device 29 for determining a maximum transmission data rate 30 or, respectively, an encoding and mapping method. Dependent on the signal-to-noise ratio 28 preferably determined in decibels (dB) according to a known relationship, the device 29 defines an encoding and mapping method or, respectively, a maximum transmission data rate 30 for the current modulation and demodulation method that enables a maximum data throughput given the existing signal-to-noise ratio 28. The maximally acceptable error rate 61 and of the modulation method 62 appear as parameters of the conversion characteristic of the device 29. Dependent on the measured transmission quality 28 of the transmission channel 11 and dependent on the current modulation/demodulation method 62 and dependent on a maximally allowed error rate in the transmission of the digital information 61, an encoding strategy (code 1, code 2,code 6) and mapping strategy (map point 1.... map point 6) can be selected in this way that, in view of the actual conditions, enables a maximum data throughput for the current modulation/demodulation method with a predetermined dependability.

The device 29 can be arranged both in the receiver 12 as well as in the transmitter 10. In any case, either the identified signal-to-noise ratio 28 or the identified maximum transmission data rate or, respectively, the selected encoding and mapping method 30 must be transmitted to the transmitter via a data connection 31.

The information about the encoding and mapping method with which a maximum transmission data rate 30 can be achieved for the current modulation/demodulation method is supplied to a control means 33 in the transmitter. On the basis of the maximally possible data transmission rate and the data transmission rate 32 respectively required for the transmission of digital information 13, this control device selects an actually employed data transmission rate 34 that is to be realized by an encoding, mapping and modulation strategy to be defined. This information data rate, on the one hand, and/or encoding, mapping and modulation method on the other hand is conducted both to the corresponding components of the channel encoder 14 of the transmitter 10 such as encoder 50, bit/symbol converter 15 and modulator 17, as well as via a data connection 35 to the corresponding

components of the channel decoder 20 of the receiver 12 such as demodulator 55, symbol/bit converter 24 and decoder 52.

The operation of the inventive apparatus upon system start of a transmission system is described below. The measuring of a transmission system is
5 meaningfully implemented with the lowest possible transmission data rate (with reference to the respective modulation method) and with the maximally possible transmission power. In this way, a low symbol error rate is assured, this being a prerequisite for a high quality of a receiver-side signal-to-noise ratio measurement. In this case, the generally utilized adaptive methods for signal editing also exhibit the
10 shortest transient times, and an optimally great system range is achieved with reference to a maximally allowable error rate. For defining the encoding and mapping method that allows a maximally possible transmission data rate for the transmission channel (and the momentarily utilized modulation method), only a single measurement is then required.

15 When, however, the desired data rate is to be enabled over different modulation methods, then a measuring procedure must be implemented for each possible modulation strategy.

The operation of the inventive transmission system during system operation is described below. Advantageously, the measurement of the transmission
20 channel ensues online based on the transmitted data stream. A lowering of the net transmission data rate for realizing a transmission channel measurement ensuing outside of the payload data is therefore not required. The measuring of the signal-to-noise ratio of a transmission data rate that is actually employed suffices in order to be able to evaluate the transmission quality even with transmission data rates realized
25 with the assistance of different encoding or, respectively, mapping rules. In advance, therefore, the system can also evaluate the transmission properties of other transmission data rates on the basis of the signal-to-noise ratio measurement implemented with a current data transmission rate. A repeated, iterative measurement for different transmission data rates is no longer required insofar as the modulation
30 method is not modified.

As long as a transmission data rate is modified only on the basis of a new encoding rule or, respectively, mapping rule and not on the basis of a modified modulation method, the adaptive methods utilized in the demodulator also remain in the steady state. A change of the data rate is therefore possible interruption-free (“soft switching”). When, however, the adaptation of the data rate is realized via a change of the modulation strategy, then the system must be measured anew and a “soft switching” is not possible.

Fig. 2 describes an embodiment wherein the maximally possible transmission data rate is determined by receiver-side determination of the signal-to-noise ratio, and this maximally possible transmission data rate is communicated to the transmission side that in turn defines an actually employed transmission data rate on the basis of the requested and the maximally possible transmission data rate and forwards this to the corresponding components in the transmitter and receiver. In contrast thereto, Fig. 3 describes an exemplary embodiment that additionally implements a control of the output power of the transmitter. The adaptation of the transmission power to the channel and to the requested transmission method is referred to below as “power control”. Insofar as Fig. 3 comprises the same devices as in Fig. 2, these are provided with the same reference characters. In this embodiment, the evaluation of the transmission quality 28 of the transmission channel 11 determined at the receiver side occurs at the transmitter side. To this end, the transmitter comprises a device 41 that, like the device 29 of Fig. 2, determines an encoding strategy or, respectively, a maximum transmission data rate of the transmission channel 11.

In addition to the transmission quality 28 determined by the receiver 12 and that is forwarded to the transmitter via the data connection 40, the device 41 also receives the data rate 32 required for the transmission of the digital information 13. An encoding or, respectively, mapping and modulation method having an actual transmission data rate 34 is selected on the basis of the respectively maximally permitted error rate for the transmission of the respective digital information 13. This selected transmission data rate 34, as in the embodiment described with reference to Fig. 2, is forwarded to the channel encoder 14 and to the channel decoder 20.

The signal values 44 generated by the modulator 14 are additionally forwarded in the transmitter 10 to a device 43 for regulating the transmission power. The signal 45 generated by the device 43 is subsequently transmitted via the transmission channel 11. The device 41 also determines the transmission power that is minimally required for the transmission. The identified transmission power is supplied to the transmission signal amplifier 43 via a transmission power signal 42.

Dependent on the difference between a measured transmission quality 46 of the transmission channel 11 and a transmission quality 47 that corresponds to the selected encoding or, respectively, mapping and modulation method (with a transmission data rate 34 and with a specific maximally allowed error rate), an adaptation of the transmission power of the transmission signal amplifier 43 is effected. I.e., when the identified transmission signal quality of the transmission channel 46 lies above the required transmission quality 47, the transmission power is correspondingly reduced. When the required transmission quality 47 lies above the transmission quality of the transmitter, then the transmission power must be raised.

In this second embodiment, thus, the difference from measured signal-to-noise ratio 46 and the signal-to-noise ratio 47 needed for the realization of a specific transmission data rate is a criterion for the boosting or, respectively, lowering of the momentary transmission signal power. When the transmission power needed for the realization of a specific transmission data rate cannot be produced by the transmission module, then the transmission system can at best realize the momentarily maximally possible transmission data rate as transmission data rate.

Such an inventive system for adapting a transmission system to the transmission channel employed is particularly suitable for employment of the “asymmetric digital subscriber line” technology. This, which is referred to as ADSL technology, like other XDSL technologies, makes traditional copper telephone lines compatible as high-speed servers for data-intensive applications. At the same time, the availability of the customary telephone voice services is preserved on the same line. Based on cabling that is already present, such technologies make data rates available that, for example exceed ISDN many times over. The limitations of the existing public information network are thus overcome, this having been hitherto

suitable only for the transmission of voice, text and graphics with low resolution. With such technologies, the traditional copper cable telephone networks becomes a high-performance system that is suitable for the transmission of multi-medium contents to all households.

- 5 By employing the traditional telephone lines, however, a high noise part is accepted, this becoming all the higher the greater the distance to be bridged becomes. The distance to be bridged in such technologies averages between 500 and 6 km. The noise part, however, increases not only with increasing length but also due to cross-talk from neighboring lines. With the assistance of the inventive, adaptive
- 10 measurement and adaptation, the transmission system can be automatically adapted with such a method to the quality of the existing transmission line.

Patent Claims

1. Apparatus for adapting the transmission data rate to the transmission quality of a transmission channel (11) comprising
a quality meter (27) for determining the transmission quality (28) of the transmission
5 channel (11), and
a definition means (29) for defining a maximum transmission data rate of the transmission channel (11) dependent on the determined transmission quality (28).

2. Apparatus according to claim 1, characterized in that the definition means (29) determines the maximum transmission data rate (28) dependent on a
10 specific, maximally allowed error rate.

3. Apparatus according to claim 1 or 2, characterized in that the definition means (29) for determining the maximum transmission data rate (28) defines a corresponding encoding method or mapping method.

4. Apparatus according to one of the claims 1 through 3, characterized in
15 that the apparatus additionally comprises a selection means (33) for selecting a transmission data rate (34) dependent on the maximum transmission data rate (30) determined by the definition means (29) and dependent on a specific, requested transmission data rate (32).

5. Apparatus according to one of the claims 1 through 4, characterized in
20 that the selection means (33) for the selection of the transmission data rate (34) with a specific, maximally allowed error rate selects an encoding method and mapping method.

6. Apparatus according to one of the claims 1 through 5, characterized in that

25 the quality meter (27) respectively determines the transmission quality (28) for different modulation methods,
the definition means (29) defines the maximum transmission data rate (30) for each of the different modulations methods, and
the selection means (33) additionally selects the employed modulation method.

7. Apparatus according to one of the claims 1 through 6, characterized in that the transmitter (10) for the transmission of digital information (13) via the transmission channel (11) contains:

a digital channel encoding device (50) for encoding the digital information, a

5 bit/symbol converter 15 for presentation of the digital information (13) in the form of symbols (16), and

a modulator (17) for mapping the symbols (16) onto signal values (18) for transmission via the transmission channel;

and in that the receiver (12) contains:

10 a demodulator (55) for converting received signal values (19) into detected symbols (23), and

a symbol/bit conversion (24) for converting the received symbol stream (23) into an encoded bit stream (53), and

15 a decoder means (24) for presentation of the detected symbols (23) as detected digital information (25).

8. Apparatus according to one of the claims 1 through 7, characterized in that the transmitter (10) additionally comprises:

an adjustable transmission signal amplifier (43), and

20 a control means (41) for boosting or reducing the transmission power of the transmission signal amplifier (43) dependent on a difference between the transmission quality (46) of the transmission channel (11) determined by the quality meter (27) and the transmission quality (47) that is required for the employed transmission data rate (34) with a specific, maximally allowed error rate.

9. Apparatus for adapting the transmission power for the transmission of
25 digital information (13) via a transmission channel (11) with a quality meter (27) for determining a transmission quality (28) of the transmission channel (11), and a control means (43) for boosting or reducing the transmission power of the transmission signal amplifier (43) dependent on a difference between the transmission quality (46) determined by the quality meter (27) and a transmission quality (47) that
30 is required for the transmission data rate (34) employed for the transmission of the digital information (13) with a specific, maximally allowed error rate.

10. Method for adapting a transmission data rate for the transmission of digital information (13) via a transmission channel (11) to the quality of the transmission channel (11), comprising the following steps:

- 5 determining the transmission quality (28) of the transmission channel (11); and
 defining a maximum transmission data rate (30) of the transmission channel (11) dependent on the identified transmission quality and on the modulation method (28) employed.

- 10 11. Method according to claim 10, characterized in that the maximum transmission data rate (32) is additionally defined dependent on a specific, maximally allowed error rate (61).

12. Method according to one of the claims 10 and 11, characterized in that, additionally, a transmission data rate (34) a mapping algorithm and a corresponding coding method is selected dependent on the maximum transmission data rate (30) of the transmission channel (11) determined by the definition means (29) and dependent
 15 on a requested transmission data rate (32) and maximally acceptable error rate (61).

13. Method according to one of the claims 10 through 12, characterized in that the transmission quality (28) is respectively determined for different modulation methods,
 a maximally possible data rate (30) of the transmission channel (11) is defined for
 20 each modulation method, and
 the modulation method to be employed is selected dependent on the maximum transmission data rate (30) determined for each modulation method.

14. Method according to one of the claims 10 through 13, characterized in that
 25 a transmission power for the transmission of the digital information (13) via the transmission channel (11) is boosted or lowered dependent on a difference between the identified transmission quality (46) of the transmission channel (11) and the transmission quality (47) that is required for the defined transmission data rate (34) with a specific, maximally allowed error rate.

16. [sic] Method according to one of the claims 10 through 15 [sic],
characterized in that the following steps are implemented for the transmission of the
digital information (13):

presentation of the digital information (13) in the form of symbols (16);

5 mapping the symbols (16) onto signal values (18);

transmitting the signal values (18) via the transmission channel (11);

receiving the transmitted signal values (21);

detecting the received signal values (21) and mapping the detected signal values onto
detected symbols (23), and

10 converting the detected symbols (23) into a detected digital information (25).

17. Method according to one of the claims 10 through 16, characterized in
that the signal-to-noise ratio is identified as criterion for the transmission quality (28).

18. Method for adapting a transmission power for the transmission of
digital information (13) via a transmission channel (11) to the transmission quality of

15 the transmission channel (11), comprising the following steps:

determining the signal-to-noise ratio (46) of the transmission channel (11);

boosting or lowering the transmission power dependent on the difference between the
identified signal-to-noise ratio (46) of the transmission channel (11) and the signal-to-
noise ratio (47) of the transmission data rate (34) employed for the transmission of the

20 digital information (13).

Abstract**Method and Apparatus for Adapting a Transmission Data Rate or a Transmission Power to the Transmission Quality of a Transmission Channel**

- For adapting a transmission data rate to an existing transmission channel,
- 5 the transmission power and/or the encoding method is inventively selected such that a maximally possible transmission data rate or, respectively, minimum transmission power can be employed dependent on the transmission quality of the transmission channel.

Figure 2



1/4

Fig. 1

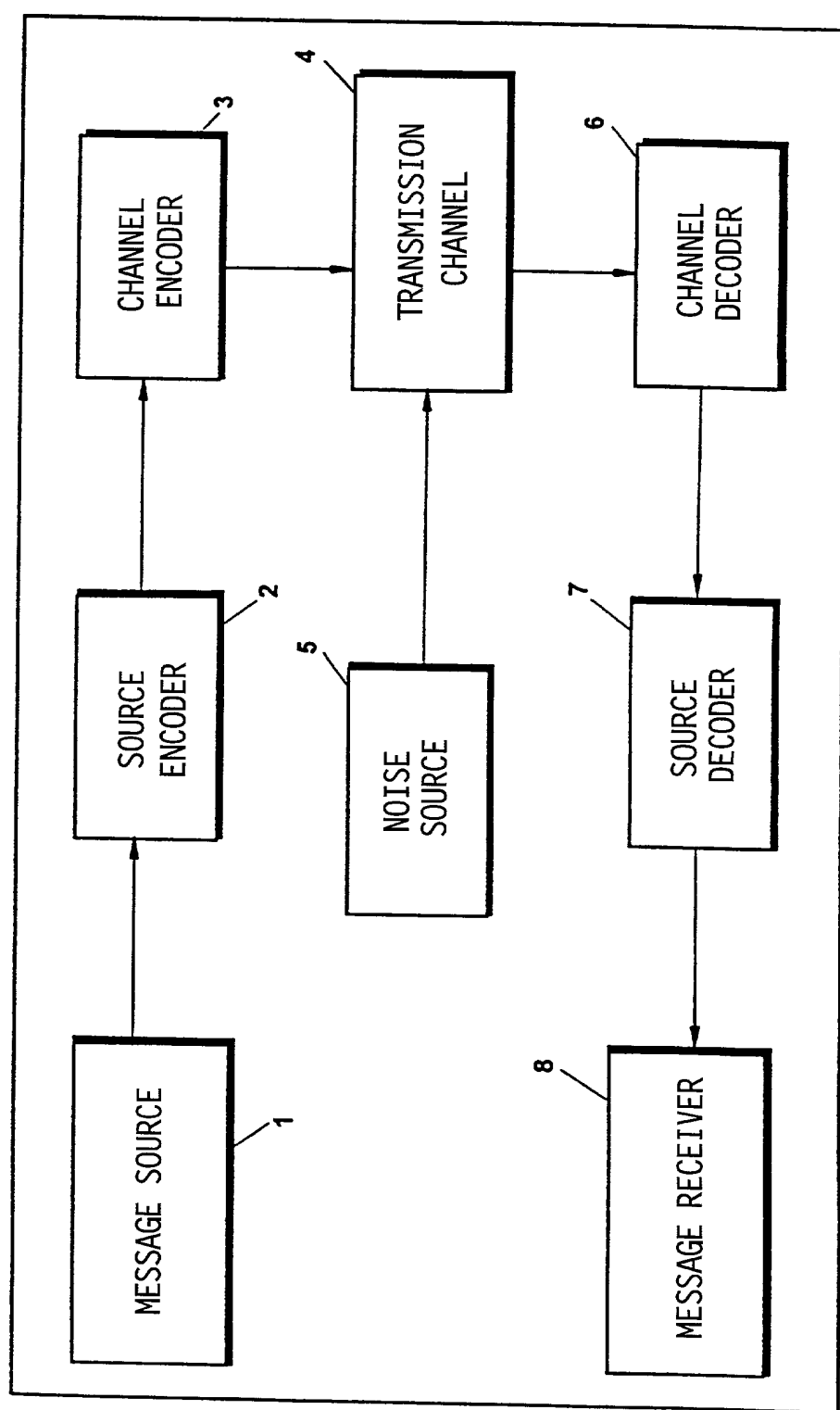


Fig. 2

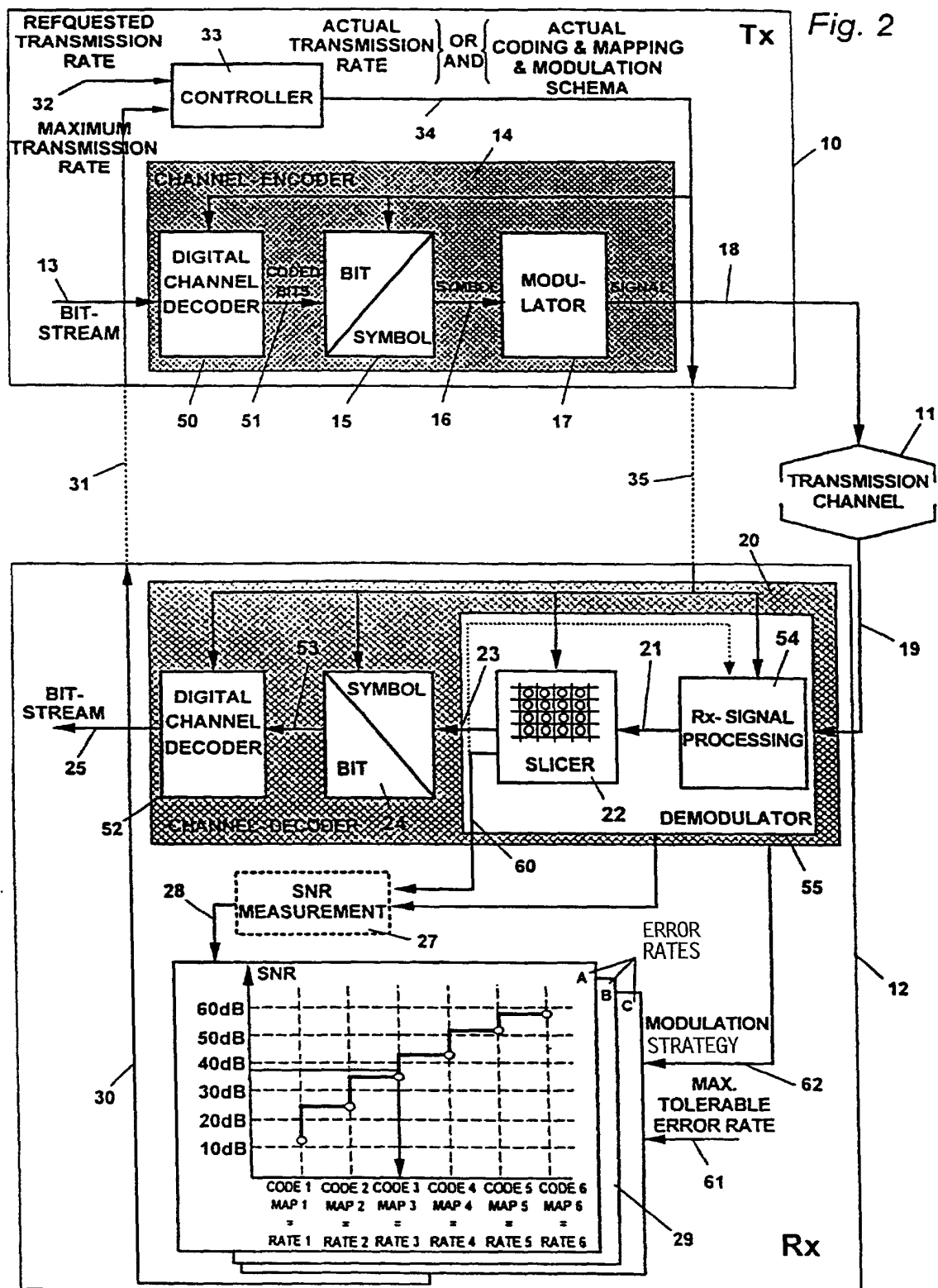
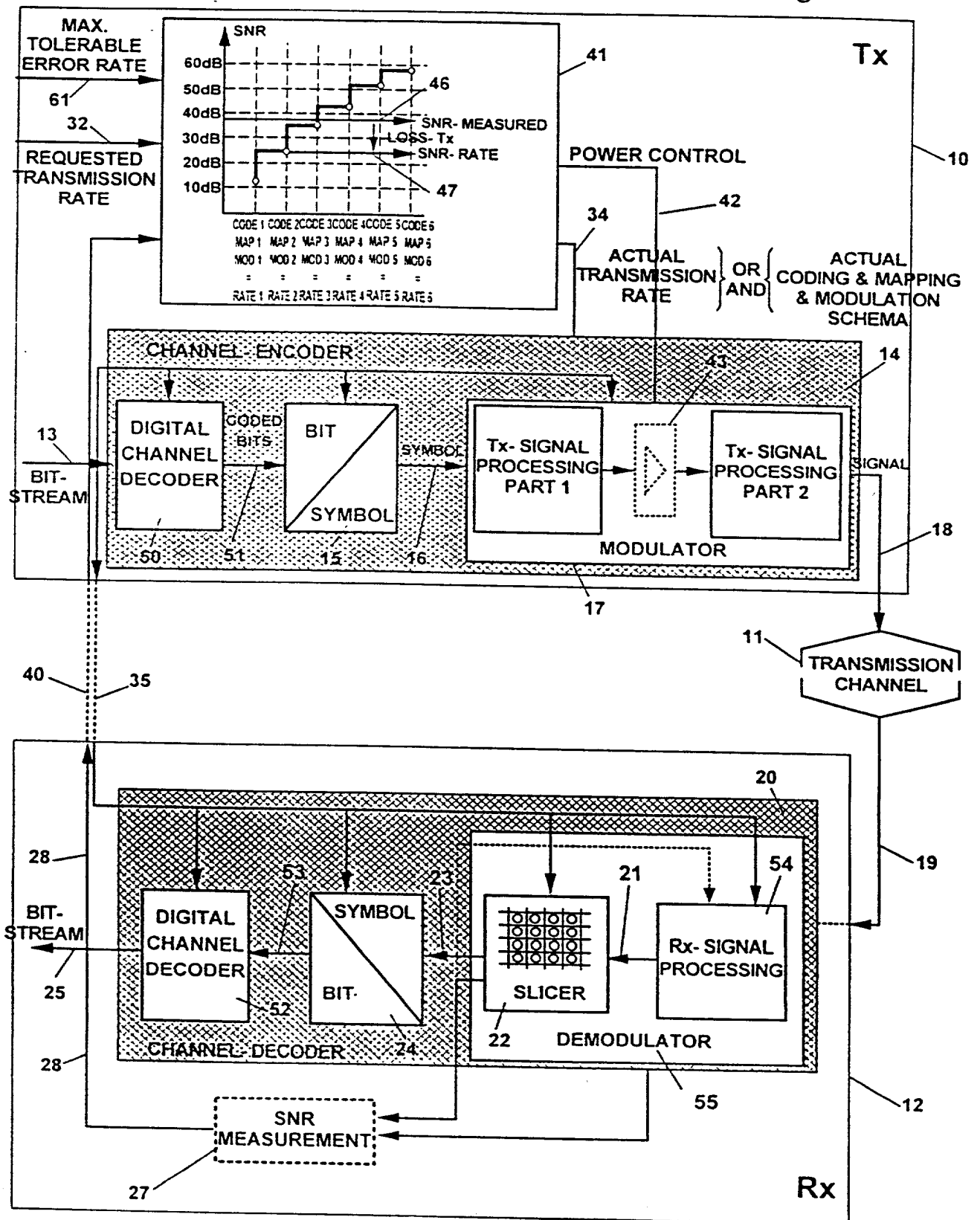


Fig. 3



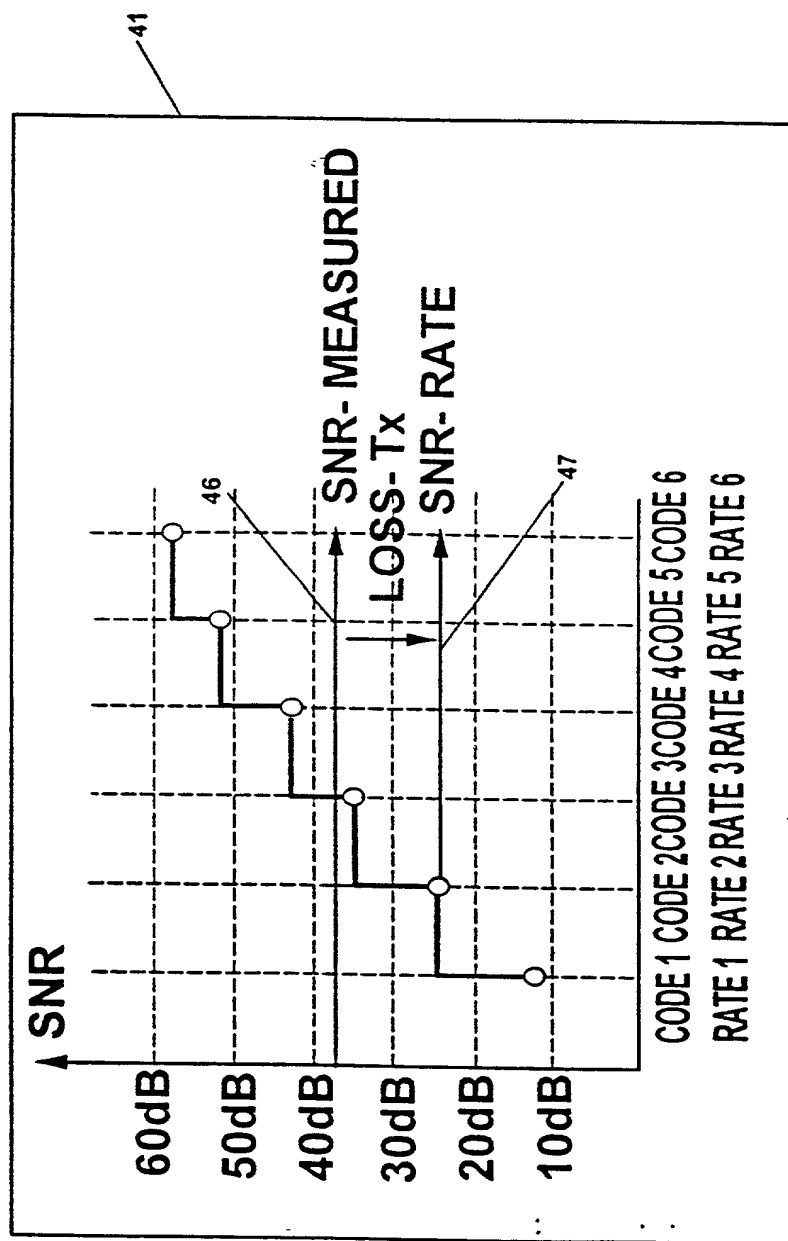


Fig. 4

Declaration and Power of Attorney For Patent Application

Erklärung Für Patentanmeldungen Mit Vollmacht

German Language Declaration

Als nachstehend benannter Erfinder erkläre ich hiermit an Eides Statt

As a below named inventor, I hereby declare that:

dass mein Wohnsitz, meine Postanschrift, und meine Staatsangehörigkeit den im Nachstehenden nach meinem Namen aufgeführten Angaben entsprechen,

My residence, post office address and citizenship are as stated below next to my name,

dass ich, nach bestem Wissen der ursprüngliche, erste und alleinige Erfinder (falls nachstehend nur ein Name angegeben ist) oder ein ursprünglicher, erster und Miterfinder (falls nachstehend mehrere Namen aufgeführt sind) des Gegenstandes bin, für den dieser Antrag gestellt wird und für den ein Patent beantragt wird für die Erfindung mit dem Titel

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled

Verfahren und Vorrichtung zur Anpassung einer Übertragungsdatenrate oder einer Sendeleistung an die Übertragungsqualität eines Übertragungskanal

deren Beschreibung

the specification of which

(zutreffendes ankreuzen)

(check one)

☒ hier beigefügt ist

☐ is attached hereto.

☐ am _____ als

☐ was filed on _____ as

PCT internationale Anmeldung

PCT international application

PCT Anwendungsnummer _____

PCT Application No. _____

eingereicht wurde und am _____
abgeändert wurde (falls tatsächlich abgeändert)

and was amended on _____
(if applicable)

Ich bestätige hiermit, dass ich den Inhalt der obigen Patentanmeldung einschliesslich der Ansprüche durchgesehen und verstanden habe, die eventuell durch einen Zusatzantrag wie oben erwähnt abgeändert wurde

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims as amended by any amendment referred to above.

Ich erkenne meine Pflicht zur Offenbarung irgendwelcher Informationen, die für die Prüfung der vorliegenden Anmeldung in Einklang mit Absatz 37, Bundesgesetzbuch, Paragraph 1.56(a) von Wichtigkeit sind, an.

I acknowledge the duty to disclose information which is material to the examination of this application in accordance with Title 37, Code of Federal Regulations, §1.56(a).

Ich beanspruche hiermit ausländische Prioritätsvorteile gemäss Abschnitt 35 der Zivilprozessordnung der Vereinigten Staaten, Paragraph 119 aller unten angegebenen Auslandsanmeldungen für ein Patent oder eine Erfindersurkunde, und habe auch alle Auslandsanmeldungen für ein Patent oder eine Erfindersurkunde nachstehend gekennzeichnet, die ein Anmeldedatum haben, das vor dem Anmeldedatum der Anmeldung liegt, für die Priorität beansprucht wird

I hereby claim foreign priority benefits under Title 35, United States Code, §119 of any foreign application(s) for patent or inventor's certificate listed below and have also identified below any foreign application for patent or inventor's certificate having a filing date before that of the application on which priority is claimed.

German Language Declaration

Prior foreign applications
Priorität beansprucht

Priority Claimed

<u>198 39 306.7</u>	<u>Germany</u>	<u>28. August 1998</u>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
(Number)	(Country)	(Day Month Year Filed)	Yes	No
(Nummer)	(Land)	(Tag Monat Jahr eingereicht)	Ja	Nein
_____	_____	_____	<input type="checkbox"/>	<input type="checkbox"/>
(Number)	(Country)	(Day Month Year Filed)	Yes	No
(Nummer)	(Land)	(Tag Monat Jahr eingereicht)	Ja	Nein
_____	_____	_____	<input type="checkbox"/>	<input type="checkbox"/>
(Number)	(Country)	(Day Month Year Filed)	Yes	No
(Nummer)	(Land)	(Tag Monat Jahr eingereicht)	Ja	Nein

Ich beanspruche hiermit gemäss Absatz 35 der Zivilprozessordnung der Vereinigten Staaten, Paragraph 120, den Vorzug aller unten aufgeführten Anmeldungen und falls der Gegenstand aus jedem Anspruch dieser Anmeldung nicht in einer früheren amerikanischen Patentanmeldung laut dem ersten Paragraphen des Absatzes 35 der Zivilprozessordnung der Vereinigten Staaten, Paragraph 122 offenbart ist, erkenne ich gemäss Absatz 37, Bundesgesetzbuch, Paragraph 1 56(a) meine Pflicht zur Offenbarung von Informationen an, die zwischen dem Anmeldedatum der früheren Anmeldung und dem nationalen oder PCT internationalen Anmeldedatum dieser Anmeldung bekannt geworden sind

I hereby claim the benefit under Title 35, United States Code, §120 of any United States application(s) listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States application in the manner provided by the first paragraph of Title 35, United States Code, §122, I acknowledge the duty to disclose material information as defined in Title 37, Code of Federal Regulations, §1.56(a) which occurred between the filing date of the prior application and the national or PCT international filing date of this application.

_____ (Application Serial No.) (Anmeldeseriennummer)	_____ (Filing Date) (Anmeldedatum)	_____ (Status) (patentiert, anhängig, aufgegeben)	_____ (Status) (patented, pending, abandoned)
_____ (Application Serial No.) (Anmeldeseriennummer)	_____ (Filing Date) (Anmeldedatum)	_____ (Status) (patentiert, anhängig, aufgeben)	_____ (Status) (patented, pending, abandoned)

Ich erkläre hiermit, dass alle von mir in der vorliegenden Erklärung gemachten Angaben nach meinem besten Wissen und Gewissen der vollen Wahrheit entsprechen, und dass ich diese eidesstattliche Erklärung in Kenntnis dessen abgebe, dass wissentlich und vorsätzlich falsche Angaben gemäss Paragraph 1001, Absatz 18 der Zivilprozessordnung der Vereinigten Staaten von Amerika mit Geldstrafe belegt und/oder Gefängnis bestraft werden koennen, und dass derartig wissentlich und vorsätzlich falsche Angaben die Gültigkeit der vorliegenden Patentanmeldung oder eines darauf erteilten Patentes gefährden können.

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true, and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

German Language Declaration

VERTRETUNGSVOLLMACHT Als benannter Erfinder beauftrage ich hiermit den nachstehend benannten Patentanwalt (oder die nachstehend benannten Patentanwälte) und/oder Patent-Agenten mit der Verfolgung der vorliegenden Patentanmeldung sowie mit der Abwicklung aller damit verbundenen Geschäfte vor dem Patent- und Warenzeichenamt: (Name und Registrationsnummer anführen)

POWER OF ATTORNEY: As a named inventor, I hereby appoint the following attorney(s) and/or agent(s) to prosecute this application and transact all business in the Patent and Trademark Office connected therewith. (list name and registration number)

And I hereby appoint
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300

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IN THE UNITED STATES DESIGNATED/ELECTED OFFICE
OF THE UNITED STATES PATENT AND TRADEMARK OFFICE
UNDER THE PATENT COOPERATION TREATY-CHAPTER II

CHANGE OF ADDRESS OF APPLICANTS' REPRESENTATIVE

APPLICANT(S): JOSEF EICHINGER ET AL.
ATTORNEY DOCKET NO.: P01,0087
INTERNATIONAL APPLICATION NO: PCT/EP99/06309
INTERNATIONAL FILING DATE: 27 AUGUST 1999
INVENTION: METHOD AND APPARATUS FOR ADAPTING A TRANSMISSION POWER TO
THE TRANSMISSION QUALITY OF A TRANSMISSION CHANNEL

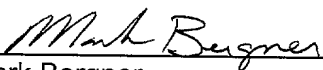
Assistant Commissioner for Patents,
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S I R:

Members of the firm of Hill & Simpson designated on the original Power of Attorney have merged into the firm of Schiff Hardin & Waite. All future correspondence for the above-referenced application therefore should be sent to the following address:

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CERTIFICATE OF MAILING

I hereby certify that this correspondence is being deposited with the United States Postal Service as First Class Mail in an envelope addressed to: Assistant Commissioner for Patents, Washington, D C 20231 on April 25, 2001.


Attorney for Applicants